HYGIENE
OF
WOMEN AND CHILDREN

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BY

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DEAN AND LECTURER ON HYGIENE IN THE HOUSEHOLD AND SOCIAL SCIENCE DEPART-
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INTRODUCTION

During the last half-century or more there has been a great
expansion of the whole subject of Hygiene. This has taken
place both in the depth and extent of our knowledge and of
our practice. When the early reformers commenced their
work their efforts were directed to the improvement of the
general conditions which concerned the community as a
whole. They worked for, and secured, great advances in
communal cleanliness—that is, in the general cleansing of the
streets, improvement in the water-supply and drainage, and
also in the methods of dealing with infectious disease. It
was, in fact, mainly with a view to the prevention of epidemics
that they pressed for the amelioration of the other con-
ditions. The latter part of last century witnessed the
consolidation of a number of Public Health Acts and the
development of the legal powers necessary for communal
hygiene by the formation of Local Sanitary Authorities.

The first step, therefore, was that of undertaking for the
people of any district work which, from its nature, could not
be undertaken by any one individual, but required the
collective efforts of the community. The present generation
is apt to take communal hygiene for granted, and perhaps
hardly realizes how much has been accomplished. Unfor-
tunately, it is necessary to add that a very great deal remains
to be done, especially in some of the great industrial towns
and in the rural parts of many counties. We know the
advantages of good sanitation; anyone can see them for
himself, since it is usually provided in the residential areas of
those towns whose poorer areas are in great need of improve-
ment. We know how disease takes hold and spreads in dirty,
overcrowded areas ; how, for example, the children in those

parts suffer from summer diarrhœa out of all proportion to
the children in areas of good sanitation. We can see, if we
will, the troubles of the housewife with dirt and flies, and the
impossibility of providing adequately for family comfort
in the insanitary and incommodious houses found in many
congested areas.

All this is dealt with in numerous text-books, and he who
runs may read. While nurses, health visitors, and other
sanitary workers may see the ill effects of bad sanitation, it
is a subject which should be studied and made their own by
women, and every effort should be made to secure improve-
ments where they are needed.

In this book passing references only have been made to
general sanitation—just to point out how general sanitation
affects the individual.

The next development of the whole subject of Hygiene was
along certain special lines—the hygiene of the child at various
ages. Thus, the school medical service deals with the child
of school age, the infant welfare work started on the infant
after birth, and spread backwards to the mother and onwards
to the child of school age. As a whole, the subject had
arisen and had of necessity been dealt with, as it were, in
sections of the community. Again, we have the special
arrangements for dealing with tuberculosis and venereal
disease, all on communal lines.

A community is, however, made up in the aggregate of
families, and these of individuals, and it is to the individual
and the home that attention has been directed in this book.
After all, it is to the individual that we must come in the
end for any concerted effort. General public health measures
will only carry us a certain way—they must be the first step
—but the final step must be by the individual. It has been
well said that people can be made neither healthy nor sober
by Act of Parliament. Acts of Parliament are, however,
essential in dealing with the impediments which prevent
individuals from working out their own salvation, but they
cannot effect this.

Much breaking up of ground still remains to be done under

the various Acts of Parliament which are now in operation for the improvement of the health of the people as a whole. But the time seems to have come when the note of individual hygiene should be sounded more loudly than has hitherto been the case. It is with a view to giving what is hoped may be some aid in this direction that this book has been undertaken. A good many important investigations have been carried out of recent years which have enlarged our knowledge of the whole subject, and an effort has been made to collect this material and to present it, so far as may be, in a simple and practical form.

Of all the branches of hygiene that of the individual is, I fear, the most difficult in practice. If carried out as it should be, it makes demands upon the person of a far-reaching nature. It is not known by instinct, and knowledge is required ; but knowledge is of no use without practice, and the practice of personal hygiene implies self-control and often self-denial. Our desires are not always in the direction of health, but the contrary, and those who would retain health must often control their natural tendencies. Self-control is not a marked feature of present-day life in general, although both health and happiness are frequently lost by allowing free rein to fancies and desires. Often, no doubt, it is due largely to ignorance, because the reason for taking care of the body has not been appreciated.

It is hoped that some of the difficulty of obtaining information may be met by this book. So far as possible, no branch of hygiene on which information was already easily obtainable has been dealt with other than in passing. In infant hygiene it may be thought that the last remark does not hold, but it is hoped that some points are brought forward here, upon which information has not, as yet, been readily accessible. The same remark applies to the chapters on milk. There are, of course, numerous large works upon this subject, but they can scarcely be held to be readily accessible. Hence it was decided to insert some chapters on this subject. It is a wide branch of hygiene, and has been condensed so as to deal with only the more important

aspects which are necessary for an intelligent appreciation of the reasons for dealing as is suggested with milk in the home, and when used as the sole food for infants.

It had originally been intended to insert one or two chapters upon sex hygiene and the physiology of the reproductive system. While the book was being written the whole subject has come very much to the front, and a number of books on special aspects of the subject have been issued. It would have been necessary, if dealt with at all, to consider the whole question at greater length than had been originally intended. The alternative was to omit the whole, as being in a sense a special branch and requiring more elaborate treatment than was possible in the space available, and this was the course selected.

There is no intention of suggesting that sex is not closely interwoven with the whole question of personal hygiene. Rather is it of such importance as to require special handling.

While this book is intended especially for nurses and health visitors, it is hoped that teachers and individuals will find it of general assistance to them in their work or in their daily life.

Throughout, the practice has been to refer constantly to other chapters and to endeavour by this means to draw attention to the interweaving of the various parts of the subject.

I am much indebted to many people for their kind aid in connection with the illustrations in this book. In especial I am deeply obliged to Professor V. Mottram for kindly preparing the elaborate tables in Chapter XVI, and also for reading over the proofs of all the chapters on food and on beverages. To Miss E. A. Stoney, M.A., for making X-ray photographs of feet ; to Miss E. Rigby Gardner, B.A., for the photographs of garments and of the shoe. I am further indebted to the following for permission to reproduce diagrams, etc., from their works, and I take this opportunity of conveying to them my hearty thanks :

To the Controller of His Majesty's Stationery Office for figs. 1, 2, 10–13, 23, 39, 40, 41, 57, 58, 60, 61, 62 ; to Dr. Charles Porter for figs. 3, 6, 8, 9 ; to the Aircraft Manu-

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HYGIENE

CHAPTER I

THE HOME

THE life of a nation is closely linked up with the position occupied by the life of the home. The habits of the country depend in great measure upon it. If the home is, as it should be, a point of attraction for the whole family, the minds of the members of the family will turn towards it. If, on the other hand, the home conditions are not attractive, then the mind will turn towards other things.

It is not the size of the house, nor the nature of its furniture or other fittings, which makes a home, but the atmosphere which reigns there. The atmosphere is made in great measure, at any rate, by the housewife. It is impossible to describe the numerous details which go to make up the atmosphere of a house, but it is felt at once on entering. Personality is impressed on the whole condition of the rooms, and is evident to those entering the house.

It is sometimes assumed that personality can only be shown if money is available to purchase such furniture as the taste of the individual will select. The actual contents of the house may, it is true, be a means of expressing personality. But it is only one method : the little details show the character of the person responsible fully as clearly as the pieces of furniture. The arrangement of the rooms, their order or disorder, the care bestowed upon the polished wood or metal, the presence of a few flowers either in pots or in a vase, the state of cleanliness of the rooms, and sundry other points all give a vivid picture of the housewife's mentality.

It is sometimes taken for granted that a woman must

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instinctively know all about her duties both as housewife
and mother. The child welfare movement has, however,
shown that knowledge of child hygiene is not obtained
through instinct, but by knowledge and instruction.
Gradually, also, it is being realized that training is necessary
for the housewife, and that the proper way to look after a
home is not learnt by instinct.

Instruction in the care of the home in all its branches
can doubtless be handed on in great measure from mother
to daughter, and up to a point this is a good method.
But many mothers of the present day have not themselves
received the necessary instruction, and cannot, therefore,
pass it on to their daughters. It is to be regretted that
in some cases mothers seem unwilling to teach their
daughters, and, it would seem, prevent them from taking any
responsibility ; in such a case the daughter may marry and
have a home of her own when she is in a state of almost
complete ignorance as to its management. In other cases,
the household duties may be presented in such a way as
to be irksome or wearisome, so that the girl has an ingrained
dislike to them, and does not learn as much from her mother
as she could.

We are often told of the great household deeds of those
of former generations—how they preserved their foods,
made their simples, etc. No doubt at that time it was very
necessary, because there was no other method of procuring
such commodities. On the other hand, the domestic arrange-
ments as recorded in books and prints of those times show
that the houses had very little comfort and were almost
certainly very insanitary, as judged by modern knowledge.
The needs and habits of the country have changed, and
domestic arrangements have changed with them. The
individual household is no longer so dependent upon its
own resources as it was, although in rural districts there
is less change in this respect than in towns or large villages.

But modern life has brought with it other requirements,
and the knowledge required in a housewife has become
extended into fields not dreamed of in the past. The

housewife of generations ago probably reached a limit of knowledge and training roughly equivalent to that of the general position of trades or professions as a whole. The care of the home appears to have been justly regarded as of great importance, and due dignity given to those who were responsible for it.

Unfortunately, the trades and professions have expanded and the level of general intelligence has risen in greater proportion than the knowledge of the average housewife. The facilities which are available for modern houses have enlarged the sphere of knowledge which the housewife should possess. She needs nowadays some knowledge of several branches of science, and instruction in many other points if she is to have anything which could be considered as an intelligent outlook upon her province. It must also be remembered that the value of money has been changing for a long time past ; it seems probable that many practices of our grandfathers and grandmothers would now be regarded as recklessly wasteful and extravagant.

The care of the home must again be raised to the proper dignity which it should possess, and for this purpose the housewife must be instructed in her duties and must have an understanding of the processes involved in the appliances which are now available. Further, she must understand the relation of the daily habits and practices to health, which of them are good and which are not. Often she may have to work under difficulties because the house she occupies does not provide the facilities ; but matters are improving in this respect, and if a housewife knows what she ought to have it is the first step towards getting it.

The whole tendency of the age is towards a simplification of labour, and there has been much outcry in recent years against the drudgery of housework. Now, while much can be done by various devices to reduce the amount of manual labour in all trades and professions, yet a small amount of work must still be done by the hands. Whatever work be done there must inevitably be some form of repetition which is often termed drudgery. It is impossible to abolish

manual work altogether in a house, but a good deal can be done towards it. The proper care of a house and family demands knowledge and intelligence, and far too little of these are available or exercised by many housewives at the present time.

There are signs that women are beginning to awaken to the true dignity of the position of an educated housewife who realizes that the best is required of her in the domestic arrangements, no less than the best is required of a man who would prosper in his work. It is not always realized how much a woman does towards making the prosperity or otherwise of her husband by the condition in which she keeps his home, and by her attitude of mind towards domestic and other matters. If a woman would regard herself as a professional worker she would realize at once the importance of a high standard for her work and that it should not be her only occupation throughout the whole of the day. She would then do her work more methodically, and would arrange time for mental and physical recreation.

There are numerous books on household management which can be consulted for details on these points. The science underlying so many household matters is not always appreciated as fully and clearly as it should be, but this is slowly improving. In the chapters devoted to the home in this book, it will not be possible to deal with detailed methods of household work. Attention will rather be devoted to the accommodation and to the facilities which must be regarded as necessary for the adequate performance of the duties concerned and for the preservation of health.

The close relation of health to housing conditions has been increasingly realized of recent years, and a great and legitimate outcry has been raised against the grossly insanitary conditions under which many people are forced to live. Clearly every effort should be made to improve the conditions, but it may be borne in mind that the conditions complained of were regarded as satisfactory at the time the houses were built. At present, through ventilation is considered a necessity; but this was not held in former days. The

insanitary conditions now so abhorrent to our senses were probably all that was regarded as necessary in days gone by. The fact that such conditions still exist means that the community as a whole does not fully realize their disastrous effects on health, and it is probable that they will not be removed until the housewife makes herself felt as a sanitarian.

A great deal has been heard in recent years of labour-saving devices. For the most part these pieces of apparatus are expensive to install and sometimes expensive to work. Doubtless with the wider distribution of electricity suitable appliances at a less cost will be available for houses and will be a great boon to the housewife. At present most of the devices are of a time-saving rather than of a labour-saving nature There is a close connection of course between the two, but there is also a distinction. Of all the time-saving devices known it is safe to say that the best and most effective of them all is knowledge, coupled with experience. If the proper way of doing a thing is known much less time is taken over it, and, as experience is gained, the nervous system works more quickly and a further reduction of time is brought about. If housework is well done it is very interesting ; but nothing is more dreary than attempting work of which one has no knowledge. Time and effort are both wasted and the result obtained is usually discouraging. The importance of a knowledge of domestic matters, expanding in a manner comparable with that of other professions, is a real need of the present day. It is felt not only in this country but in nearly every country of the world which is making any attempts towards progress. It is an encouraging feature, because the home is the basis of national life.

The shortage of houses, which has been felt acutely as a result of the great war, has brought into prominence the standard of domestic accommodation. This standard, which had been slowly rising before the war, effected a great leap forward in a very short space of time, as a result of the general rise of level of living among the working-class population. What is now regarded as minimal would, in years past, have been considered luxurious, and in fact the present

" minimal " accommodation can well be regarded as adequate for any person, from the hygienic standpoint. Some extension of the standard may be desirable according to size of family, etc., but that given may be taken as suitable for any citizen.

Before the war it was estimated that about 90,000 to 100,000 houses were built each year ; of these some 95 per cent. were built by private enterprise and the remaining 5 per cent. by Local Sanitary Authorities. The Local Sanitary Authorities, with one or two exceptions, did not build largely, on account of the risk of incurring a considerable annual charge on the rates. Public bodies build at financial disadvantage in most cases, and it was generally felt to be unjustifiable to burden the general rates with the charge of houses occupied by only a small section of the community. The schemes had to be roughly self-supporting, if undertaken. During the war all building of houses was stopped, and the Rent Restrictions Act prevented any general rise in the rentals of small houses commensurate with the demand for them. Meantime the cost of labour and of building materials rose to a great price, so that, if houses were to be built as commercial enterprises, it would be necessary to charge greatly increased rents. There was no chance of obtaining such a rent, because the rents of pre-war houses had been kept down artificially, and it was felt that the working-class population, who were in need of houses, would be neither willing, nor, in some cases, able to pay the necessary rent. Private enterprise could not therefore build these houses, at any rate without subsidy from the State. In order to meet the urgent need for houses and the difficulty or impossibility of securing their construction by private enterprise, it was decided by Parliament that the duty of building the houses required should be laid on Local Sanitary Authorities, who should be aided by large State grants. In general, the Local Sanitary Authority has to provide the money for the actual building and the State grant is intended to cover the greater part of the deficit on the annual outlay. The rents charged are only a small part of the cost incurred each year

by the Local Sanitary Authority; but the economic rent—
that is, one which covered the cost—would not be paid by the
working-class population in view of the relatively low rents
paid for existing houses. More latterly, subsidies have been
paid by the State to private builders who were prepared to
construct houses of suitable type and to conform generally
with the requirements of the Ministry of Health. The plans
of the houses built must be approved by the Ministry. In
order to facilitate their construction, the Ministry set out
certain model plans, which are valuable aids in the planning
and general arrangement, and of which some samples are
given in the following chapters.

The subsidy will not be continued beyond a certain
period as yet not fixed, and it may be hoped that, with a
return of more normal prices and conditions, the housing
problem will be eased in conformity with the laws of supply
and demand.

CHAPTER II

THERE are many points which are of importance in the general arrangement of new houses. If built in or near a town, provision must be made for the occupants to have the use of the various services now regarded as forming necessaries of life. Roads are needed, and these should be properly finished, and pavements provided. An unmade road is often dirty, and the dirty boots and the mud these bring in from it add materially to the work of the housewife. Trees or shrubs planted in the roads add to the general amenity, and, when they are grown, provide a pleasing appearance and welcome shade and breeze in summer weather. The position occupied by the house is of more importance than is generally realized. It is rare in this country that the sun is too hot, even in summer, and the presence of sunshine in the house makes a great difference to both mental and bodily health. Rooms which are to be the chief place of abode of the family should not face north. The living-room should get such sunshine as is available, and in general the houses should be planned so that as many as possible of the living- and bed-rooms should have sunlight and warmth. Anyone who has been obliged to spend most of their time in a house whose main rooms face north will readily appreciate the advantage of having sunshine.

Long rows of houses are dreary and should be avoided. Blocks of from two to four houses can be prettily arranged and afford greater opportunities for a pleasant lay-out. Samples of lay-outs as suggested by the Ministry of Health for the new schemes are to be found in the *Manual on the Preparation of State-aided Housing Schemes* [1] (see fig. 1).

[1] Published by H.M.'s Stationery Office, 1919.
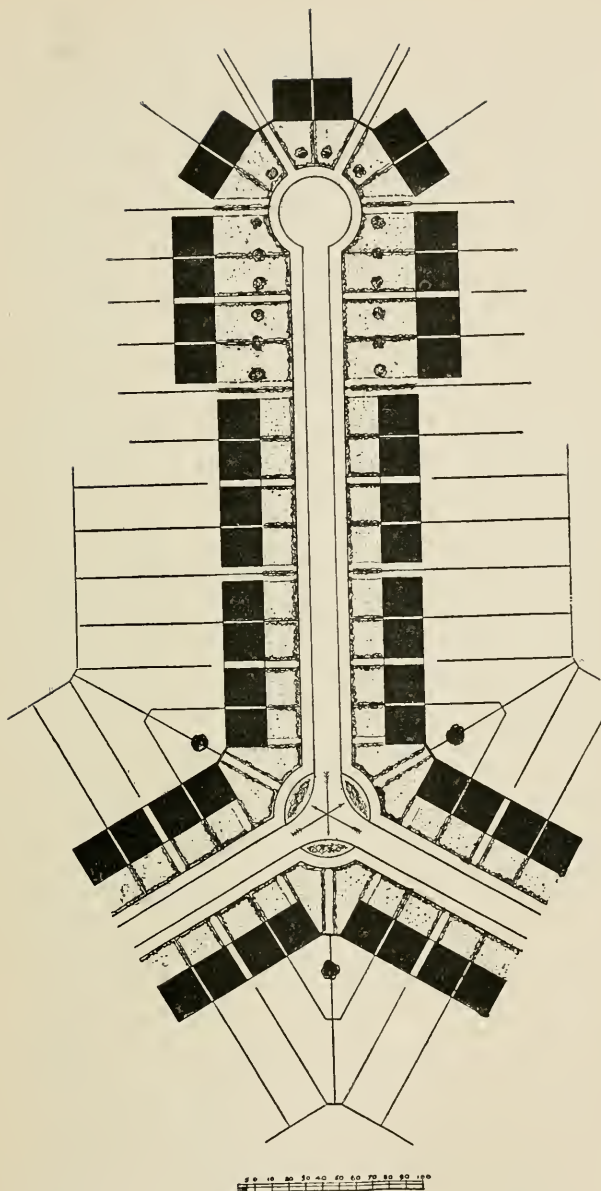
FIG. 1.—Showing a model lay-out for houses : note the gardens and
the passages leading to the back.

(*By permission of His Majesty's Stationery Office.*)

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Fig. 2.—Showing an old scheme adapted to new requirements.
(*By permission of His Majesty's Stationery Office.*)

The one shown in fig. 2 is taken from another publication of
the Ministry of Health,[1] and demonstrates the adaptation of
old schemes. This should be compared with fig. 3, showing
a common form of arrangement of older houses in the middle
and north of England.

The following photographs are also of interest as showing
differences of lay-out. (Cp. figs. 4 and 5.)

It is usual to keep the ground in front of the house for
ornamental purposes ; there will be a path up to the front
door, flowers, grass, or shrubs filling the rest of the
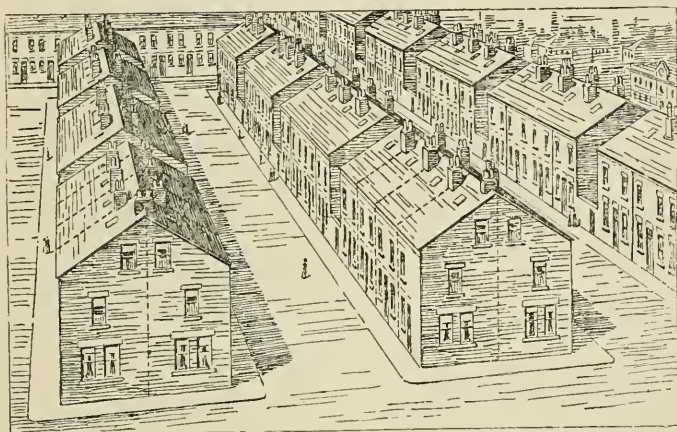
FIG. 3.—The dotted lines show the position of the partition walls between
the houses. Note the gaps at intervals of every four houses : the sanitary
accommodation is placed there.

space. It is useful if a part of the ground at the back
is laid down with concrete, forming a clean part near the
house. Out-houses and offices, if built, are usually low,
and should be connected with the house by a protecting
roof if possible. It is less usual nowadays than formerly to
have a projecting part of the house behind, since this may
keep away some sunlight, and somewhat prevents free
ventilation. The tendency is to arrange for all the offices
to be inside the walls of the house proper. The back part
should either be paved or used as a garden and be well kept.

[1] *Housing*, September 13, 1919.

FIG. 4.—Air photograph of Earswick, near York (for employees of Messrs. Rowntree & Co., Ltd.). Note the general lay-out, the gardens, trees, and general amenity of the site.

(Reproduced by permission of the Aircraft Manufacturing Co.)
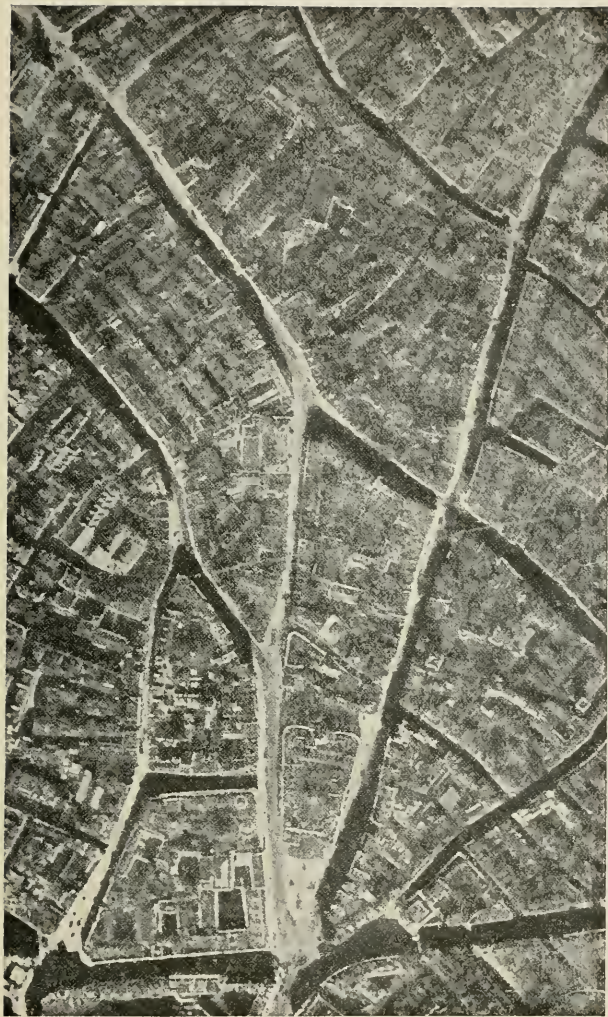
Fig. 5.—Air photograph of the East End of London. Note the irregular and crowded arrangement of the houses and courts, the absence of open spaces, etc.

(Reproduced by permission of the Aircraft Manufacturing Co.)

The paths should be made up, and should not be left untidy and dirty. All this makes a difference when there are little children continually running in and out, who will make themselves and their clothes dirty with great ease if the path or garden-plot is in a bad condition. In addition, such unmade areas tend to become rubbish-heaps, and the soil gets trodden and sour; further, they retain the damp and are a source of ill-health. An important point in the situation of a house is that of dampness or dryness. Houses should not be below the level of a river, or too near any low-lying water. The close vicinity of large trees will also make a house damp, because the drip from the trees will fall on the house and large, heavy trees remain damp for some time after the rain has ceased.

A damp house is usually an unhealthy house. There are domestic difficulties because the food keeps very badly, and is a source of constant worry to the housewife. The rooms do not feel dry and cheerful, for a damp room always tends to be gloomy and chilly; generally speaking, it means, for some reason or another, that the sun is not able to reach it for long in the day. Houses in valleys get less sun than those on a hill. Dampness has an effect on the general health of the inhabitants, tending to rheumatic troubles; also tuberculosis is not uncommonly associated with dampness, which presumably lowers the general powers of resistance to disease.

It is a pity that the rain-water falling on the roof is so seldom collected in towns, but allowed to run away into the drains. Rain-water, it is true, may be somewhat dirty, but if it is led into a proper cistern or covered barrel it can be used for washing. This is a great advantage and economy to the housewife, as it requires less soap, and cleanses the body and clothes more rapidly than the water from the general supply, which is practically always harder than rain-water. In country districts the rain-water is very frequently collected, being allowed to run into a large barrel or tank in the back yard. The receptacle should be kept covered to avoid the dropping in of dead leaves and other matter.

The dust-bin should stand in the back yard in towns, duly covered with a well-fitting lid, and reasonably accessible to the dust-man. In some districts the dust-bin is fixed in the wall, access being gained by the housewife on the inside and the dust-man on the outside. Samples of sanitary bins and of an insanitary rubbish-heap are shown in figs. 6 and 7.

Narrow back roads passing between the back yards or gardens of rows of houses are seldom well kept, but are frequently the place for the collection of refuse which has gradually accumulated and not been removed, as is done in the main road. As a whole, it is found preferable to arrange for passages from the main road giving access to the back
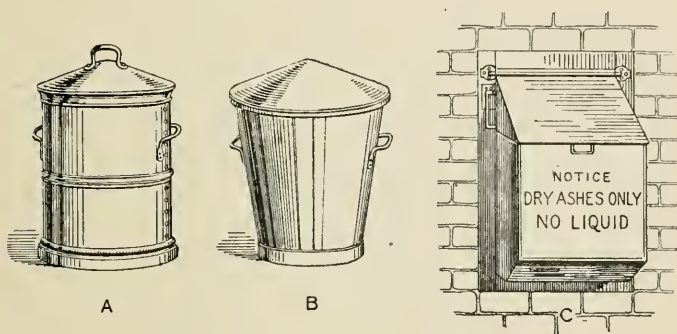
FIG. 6.—Samples of sanitary bins.   C is fixed into the wall.

parts, without going through the house. There is then no need for a back road. This is seen in fig. 1.

Too often in the past the amenities of life have not been considered, and houses have been built in any nook or corner, without through ventilation, and in a position where the ordinary conveniences of life were almost impossible of provision.

The number of houses allowed to the acre under the new schemes is twelve in the town and eight in the more rural areas. This provides sufficient space for both a front and back garden or yard, and gives plenty of air and opportunity for obtaining sunlight. These pieces of land are of great value to the occupiers. If there are infants or quite young

children in the family, they can be put out in the peram-
bulator in the garden. They can be sufficiently under the
mother's eye to make it safe, and the child's health benefits
greatly. The garden, both front and back, provides flowers
and green vegetables, together with the healthful exercise
and pleasant occupation necessary to produce them. On
washing days the housewife can hang her clothes out on a
line in the back yard and garden, thus relieving the kitchen
of the steam from the drying clothes. In many cases,
too, pets will be kept in the yard, all providing interest
and instruction for the children. In some places larger
animals will no doubt be found. One district councillor
in Yorkshire recently publicly expressed his opinion that
a pigsty outside the house would be more useful than a
bathroom inside it, there being only a limited amount of
money available—an opinion which at least shows the value
of pigs to the family, in his mind, and probably in that
of many others.

The advantages of a garden just enumerated have slightly
different weight in town and country. In the country the
family will probably be dependent on their garden for the
supply of their vegetables, whereas in the town green foods
can be purchased. There may be allotments, which will
enable them to grow sufficient for the family needs ; but in
most cases they will prefer to have the garden for this pur-
pose, since it is more convenient. It is by no means always
easy to buy fruit and vegetables in small quantities in the
country ; but these are important, even essential, articles of
diet. There will be greater freedom in the kind of animals
or birds kept in the country, because the area of the garden
will be larger, and also because the fowls, if kept, can
frequently wander into adjacent fields or roads.

Then, again, the garden serves as a means of dis-
posing of refuse of all sorts. In a town the domestic
refuse is collected, or should be collected, regularly by the
Local Sanitary Authority. In the country such arrange-
ments are often too expensive ; the housewife must deal
with it herself, and the garden will be the better for
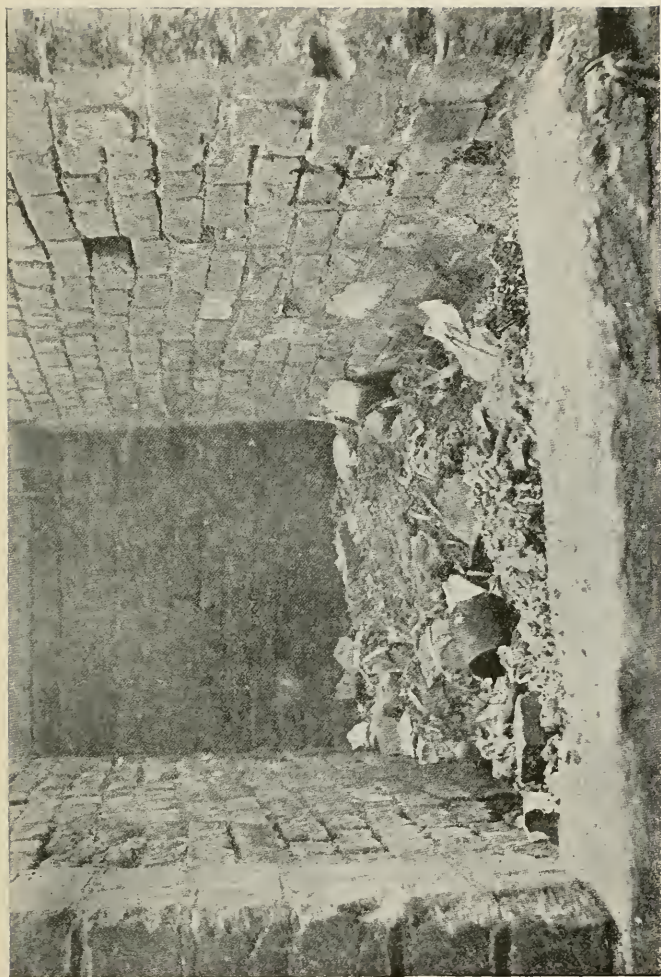
FIG. 7.—An insanitary rubbish-heap.

receiving the refuse. There should not be a great deal of material to dispose of, although there will always be a little. Some can be burnt, and the fowls or pigs, if these are kept, will eat most of the rest, especially if the harder parts are cooked. But cabbage stalks and such-like will remain, and there will be ashes from the fires which must be disposed of. Too often they are tossed into a specially prepared open pit, or ash-place, or are even thrown in a heap, and there left to rot under the influence of the sun and the weather. The ash-place will attract dogs, who will scratch about in it, scattering the refuse and becoming themselves covered with pieces of the decaying substances. The flies also will come and will breed there, constituting a menace to health, and causing much nuisance and general discomfort.

If any form of receptacle for refuse is used outside the house it should be a metal bin with a properly fitting lid, which last must be kept always in its proper position on the bin. The ashes can be kept separated and used for the garden paths, or, if the soil be very heavy, some ashes may be used for lightening it. The vegetable and other refuse should be deposited in a trench in the garden. The trench need not be very deep, and can gradually be filled in day by day with refuse. The refuse must, however, not be left uncovered but must have several inches of earth over it, and earth must also be placed at the end, as it were, of the refuse thrown in each day. The earth prevents the access of flies—a matter of great importance. The refuse has some manurial value, and will be decomposed in the ground, returning again to its original elements, so that after a while it will be amalgamated with the soil. A part of the garden should be available for the trench, and, when this is full, another trench can be dug elsewhere and the area of the filled-up trench can shortly afterwards be used for growing vegetables.

Fowls and pigs should have their dwelling-places kept clean, both because they thrive better if thus kept, and also to avoid the breeding of flies or of vermin in the poultry place or pig-shed. The refuse from green vegetables which

cannot be used for the domestic stockpot can be boiled and mixed with the other soft food for the hens. For the pigs it is probably waste of time to boil the material. Hens, however, take a long time to eat hard pieces of refuse, such, for example, as cauliflower-leaves or cabbage-stalks, which thus lie about looking untidy for several days. If, however, these are cut up and boiled they are readily eaten. Most other varieties of domestic refuse which cannot be given to animals can be burnt on the fire.

Offal, when present, is best buried in the garden, and this may also be the fate of refuse which is not burned or given to the fowls. Thus, with a little trouble, there should be no accumulation of waste material in or near the house. Flies will breed in any such place, and flies are the carriers of disease germs, in addition to making the walls and other parts of the house dirty. Real cleanliness is almost impossible where flies are present in large numbers. The essential point is that there should be no breeding-grounds for flies, and this the housewife can secure by the above simple measures.

The refuse which has been considered hitherto is the dry refuse from kitchens and fires, but there are other forms of waste material, where the garden is equally or more useful as a means of disposing of it.

The excreta, both solid and liquid, should in a town be removed by the water-carriage system. Unfortunately, especially in the North of England, this is by no means always the case, and further reference will be made to this. The inhabitants of a house in the town cannot themselves make provision for the removal of their refuse, but are dependent upon the arrangements made by the Local Sanitary Authority and by the landlord. In the country, the excreta must be dealt with by the householders. Too often, even now, a hole is dug in the ground, and a little shed with a door is provided, a seat with a hole and a lid being built in the shed over the hole. The excreta are deposited in the hole and left to filter through the earth or to decompose, as the case may be. This is thoroughly unsatisfactory for several reasons.

In the first place, the fluid may contaminate the water-supply by filtering through the soil into the area from which the water-supply to the well is derived. If the well be a deep one—taken, that is to say, through the top layer of soil—the risk is less great ; but if a shallow well is used—that is, one in the top layer of soil—then the risk is very real. The distance apart—that is, the relative position—of the two places will alone provide the margin of safety. In any case, the well should be placed above the
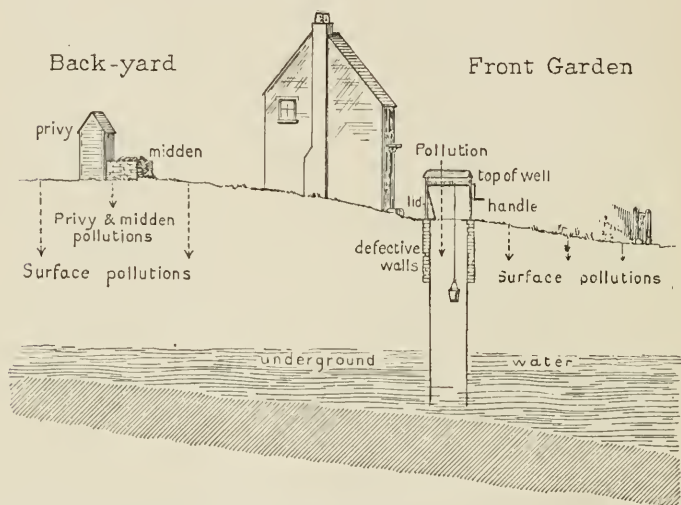
FIG. 8.—Showing how the water-supply of a house may be polluted owing to a wrong position of the privy.

closet, so that the contamination does not filter into it, and they should be as far away from each other as possible. Fig. 8 shows the relative positions which will give rise to pollution. The position should be reversed.

Then, again, it will almost certainly be productive of bad odours and be a breeding-place for flies. If the lid were always kept on the seat, so that the flies could not enter, this might be avoided. But flies breed freely on excrement, and generally they will gain access to the closet and breed there.

The best form of receptacle for excreta in a country house is the earth- or ash-closet. It may be provided either inside or outside the house. There is no odour, and its only disadvantage is that it requires attention and a little trouble. If placed outside, the closet should be adjacent to the house, and any part of the yard which may have to be traversed should have an overhead shelter from the rain. The floor should preferably be of concrete, slightly raised at one part near the back whereupon to receive the pail. The pail is placed on the elevated part, and a hinged seat should be fixed to the back wall of the shed so that it can be pulled down and lie over the pail when required for use. Near by there should be a box or other receptacle with earth or ashes, and a shovel is also needed. Each time after use earth must be thrown over the excreta so as to cover them adequately. The pail should be emptied at sufficient intervals, depending upon the amount of use, but should not be left for more than three days. The contents can be emptied into the same trench as receives the dry refuse already referred to and the method of use of which has already been explained. By this means no nuisance arises and the whole closet can be kept clean and sweet.

Portable earth-closets can be bought which have a place for the pail and an upper part behind which will contain earth or ashes (see fig. 9). This is fitted with a valve. which can be opened by pulling a plug at the side or back of the seat, and the earth or ashes fall on to the excreta. In some ways this is convenient, but hygienically it has no advantage over the box and shovel. The portable closet can be placed in any shed or suitable room. The earth-closet must be clearly differentiated from the pail-closet. These are merely pails without any earth or ashes, which are emptied at intervals (often too infrequent) by the Local Sanitary Authority. They are very unhygienic, and the emptying is costly. There is a wide distinction between the clean, frequently emptied earth-closet and the pail which is used merely as a receptacle for excreta and emptied, say, twice a week or even less frequently.

Another method used in the country is the water-closet with cesspool. Theoretically the cesspool is supposed to be water-tight and to be emptied at frequent intervals. Actually, however, this is almost impossible, and the cesspool is not water-tight, the fluid draining away through the ground. If the cesspool be near the well there is great risk of contamination of the water-supply. It should be mentioned that, in selecting the ground for entrenchment for the con-
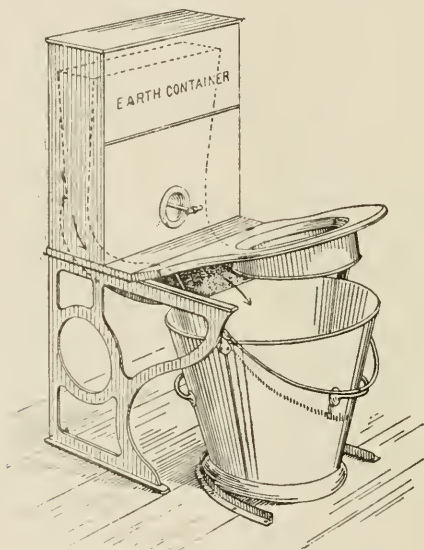
FIG. 9.—A portable earth-closet.

tents of the pail, the area near the well, if there is one in the garden, should not be used for making trenches. Also cesspools or pits should be placed as far away as possible from the water-supply, and, if the ground is sloping, the well should be above the pit. The contaminated material should drain *away* from the well as it passes through the ground.

In the absence of a garden the use of an earth-closet in the country is almost impossible, both on account of the difficulty of obtaining earth and also of disposing of the contents of the pail. Neighbouring farmers are sometimes

willing to make an agreement to remove the refuse, which has some manurial value.

There is yet one other waste material which can be disposed of in the garden, namely, dirty water. This will come from personal washing, the scrubbing, and house generally. The waste water from the kitchen and the bath is led out of the house by a pipe, which usually discharges over a gully. The water is led away to soak into the earth. If the weather is dry and the waste water small in amount, no trouble may arise. Sometimes, however, the ground gets water-logged and the waste water is not filtered away, so that the earth becomes muddy, and the organic waste in the dirty water may decompose and produce a disagreeable odour. The area over which the waste water soaks in should be reasonably large. Perforated bricks, arranged so as to form a gully, are easily provided and allow the water to enter the ground over a large area. The fluid will run along the gully, losing some of its volume as it passes over the perforations. The cottage housewife can often be seen throwing the contents of her pail to some distance in a wide curve. She has realized the advantages of a larger area of distribution.

The water from baths and wash-basins, if the rain has not fallen plentifully in summer-time, can be poured on to the flowers and vegetables, thus utilizing waste to produce growth. Kindly mother Earth receives the waste and converts it to useful purposes, so that refuse causes growth and the herbs can be used as food, the stage of refuse being only one phase in the larger cycle.

CHAPTER III

ON ACCOMMODATION AND OTHER GENERAL POINTS IN THE HOME

THE precise amount of accommodation required in the home will vary somewhat with the size of the family. In this chapter the general assumption will be made that the family consists of the two parents and of from two to four children. The differences in accommodation will thus be mainly those for sleeping, the other rooms needed being very similar, whatever the size of the family. There should be not less than three bedrooms—one for the parents and one for the girls and a third for the boys of the family. If the family is very large further accommodation will be needed.

Various types of accommodation, according to aspect and plan of living-rooms, have been set out by the Ministry of Health, and are reproduced in figs. 10–13. They should be referred to in reading the text of this chapter.[1]

As a rule, except perhaps in bungalows in rural areas, the living-rooms will be downstairs and the bedrooms upstairs. There is considerable difference of opinion as to the desirability of one or two living-rooms. Some people think that one large living-room is preferable to one smaller kitchen and parlour. Where space is limited it is hardly possible to provide two good rooms. If the kitchen is to be used as a general living-room, then there should be a good scullery leading out of the kitchen (cp. fig. 10), where small dishes, at any rate, can be cooked and all the washing-up and other dirty jobs carried out. The living-room must be kept reasonably tidy and comfortable. In winter it will be warm, as the fire will be used for cooking ; in summer, unless gas is available, it may be too hot. In towns at the present time gas is largely used for cooking in summer, and in the country

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[1] These plans are reproduced by permission of His Majesty's Stationery Office.

the heat is seldom so great as in the towns. If the house faces north the one living-room may be carried right through
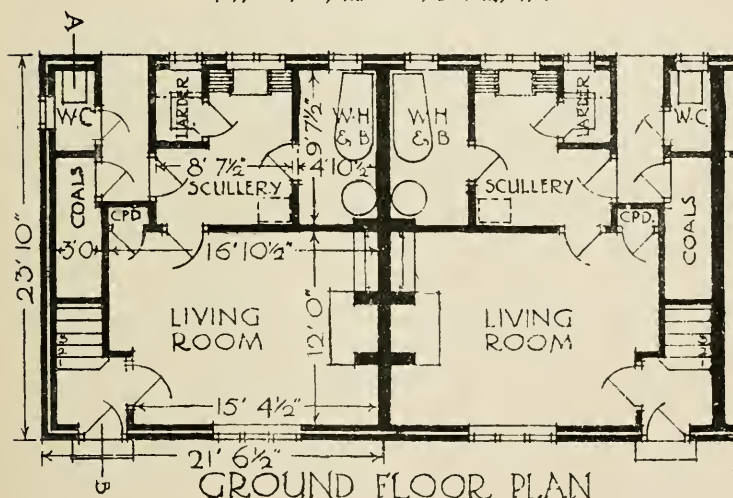
Fig. 10.—Plan of houses with one living-room and three bedrooms. Frontage to the south. Note that the larder faces north.

the house, so that it gets good through ventilation and sunshine (cp. fig. 11).

There is much also to be said in favour of two living-

rooms, in spite of the rather general assertion as to the small use made of the parlour (cp. fig. 12). It is a change to have a second room for work or for those members of the family who have to study or who are working for any special purpose, or in which to entertain their friends.
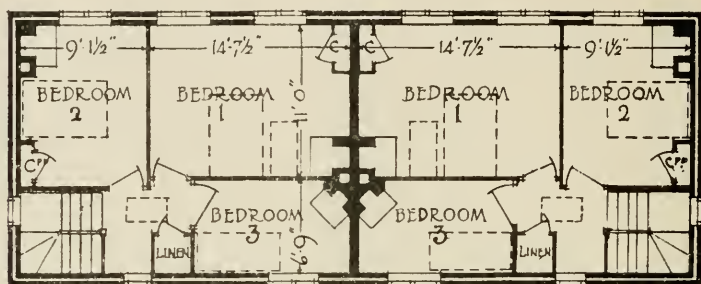
FIRST FLOOR PLAN
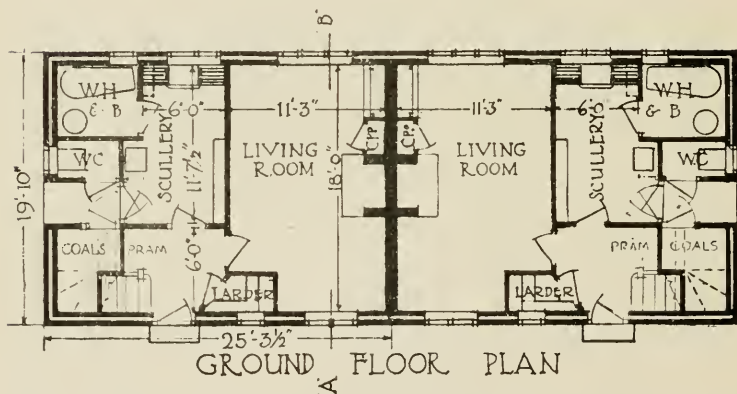
GROUND FLOOR PLAN

Fig. 11.—Plan of houses with one living-room and three bedrooms. Frontage faces north. Note that the living-room is carried right across the house to secure direct sunlight, and that the larder is placed to the front, facing north.

Generally it seems that there is a preference for two living-rooms, even though each room be of less size than the one large living-room.

It is of importance, in planning the doors and place for the fire, to avoid draughts. It is not always possible to

provide a lobby both at front and back, and the door out of the living-room may open directly on to the garden or road. If the door on the other side of the room is badly arranged in respect of the front door there may be a
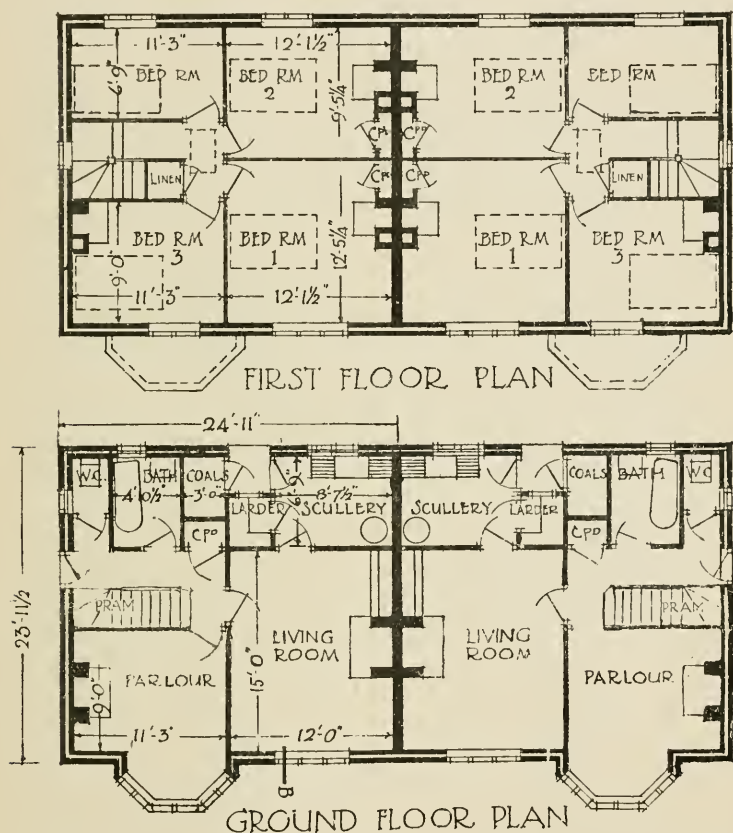
FIG. 12.—Plan of houses with two living-rooms and four bedrooms. Frontage faces south.

draught right across the room. If, further, the fireplace be set in the line of the draught, it may be impossible to keep warm in the room. So far as may be, the door or doors should be kept at one end or side of the room and the fireplace at the other. There will almost inevitably be a draught

between the doors, and these should be as far as possible away from the fire, around which the occupants will sit to keep warm in winter. The position of the doors on the plans should be noted in illustration of this point. The outside doors do not open directly into the living-rooms, and the inside doors to these rooms are not placed directly opposite the outside ones. The side door in place of the front door is often good, as shown in figs. 12 and 13. The windows must be of sufficient size to admit plenty of light and sunshine, and must be capable of being well opened to admit the air. Windows down to the ground are nice to look at, but they are always somewhat draughty, and rooms with these windows are rarely warm in winter.

Some of the older houses, found even now in the Midlands and elsewhere, had no windows capable of opening in the lower rooms. In many cases a small window has now been made to open, so as to secure some ventilation. In the back-to-back houses (cp. fig. 3, p. 11), still found in thousands in the Midlands and North of England, no through ventilation is possible, because the same wall forms the back wall of the two houses. There is one living-room on the ground floor, often opening directly on to the street, through which some change of the air in the room is secured. Even with the best intentions, by keeping the door open as much as possible, it seems very difficult to obtain any appreciable circulation of air in the back part of the room; after a little experience, back-to-back houses can be identified as such on entering them by the smell and general atmosphere of the living-room. Some ventilation, it is true, occurs through the crannies in doors and windows. Some air also passes through the walls, but in insufficient amounts to replace the need for a through current of air at suitable times.

It is usual to have the floors of the parlour and bedrooms of wood, but the kitchen and scullery floors may be of tiles or flat bricks. In any case these latter should be used for the offices, but there are certain other considerations in regard to the kitchen floor. Tiled floors are less trouble to clean than wooden floors; but they are cold in winter. Another disad-

vantage lies in the fact that the tiles are harder, and any crockery or other breakable article which is dropped on to a tiled floor is nearly always broken beyond repair, which is not the case on a wooden floor. Tiles wear longer than wood,

FRONT ELEVATION

8' 0"

8' 0"

SECTION AB   SIDE ELEVATION
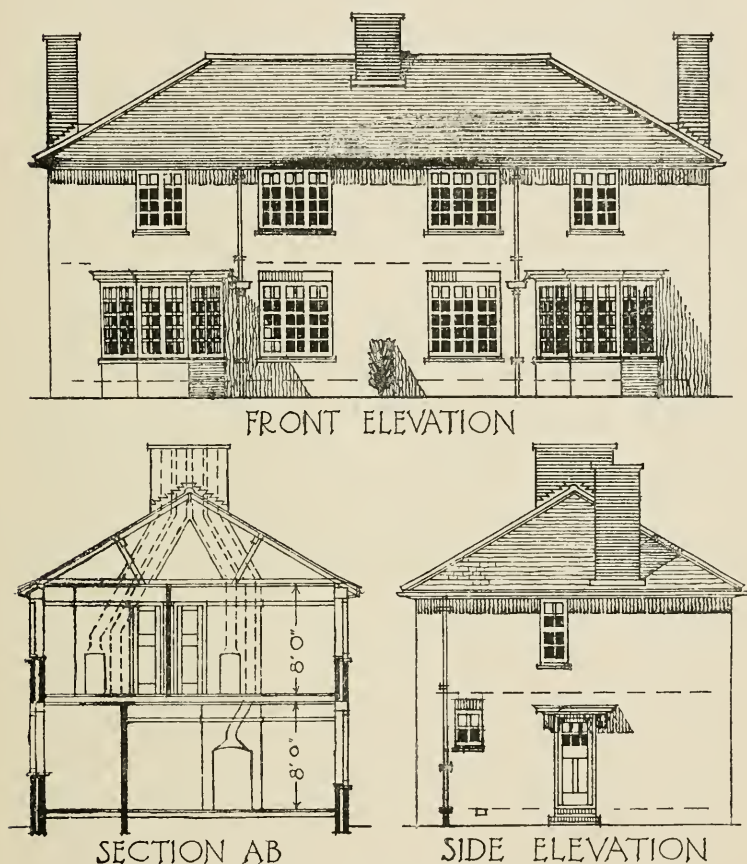
Fig. 13.—Elevations and section of the houses of fig. 12.

and are generally regarded as being more hygienic. But much depends on the housewife and on the condition of the floors. There are tiled floors in old houses where the tiles have been laid practically on the ground and where, when

they get loose and worn, they allow of the dirt coming up between the edges and give much trouble to keep clean.

Boards, however, if they are badly worn, are sometimes dangerous. In certain of the poorer houses in the worst districts the boards are worn and rotten, and there are actual holes in the floors which show underneath the accumulated dust of many years, while the state of the boards is a constant danger to the small children and even to the elders of the family. As a council of perfection, the angles of junction of the walls and floor should be rounded. This prevents the dust from sticking at the junction and enables the housewife to clean easily. Unfortunately this can only be regarded as a luxury at the present time on account of the high initial cost of providing the curved parts.

The high cost of wall-paper has tended to increase the use of distemper of various kinds in place of paper for the walls of both living and bedrooms. There are advantages in distemper over wall-paper, although some people like the patterns provided by the wall-paper. Many of the present-day varieties of distemper can be washed and the walls kept clean for a number of years. Redistempering is less expensive than repapering. For this reason distemper is preferable for offices where use and the need for special cleanliness makes frequent rewashing necessary. If wall-paper is used one layer should not be placed on the top of the other, thus merely covering up dirt and not removing it. Plaster sometimes gives trouble, when it begins to fall away. If it gets into really bad condition it may be continually crumbling, making much work to keep the room clean.

Flies are a cause of great difficulty and trouble to the cleanly housewife. If the house is near one of the breeding-places, such as a privy midden or a rubbish-heap, they will make the walls and furniture very dirty. Everyone is familiar with the excremental deposits left by flies and the trouble there is to remove them.

The scullery should be adjacent to and open out of the

kitchen. It can face north, as there is no object in securing sunlight, since it will not be occupied for more than short periods ; the light should, however, be good. The scullery should be provided with a sink and draining-boards, and a plate-rack over the sink. There should be a copper for boiling clothes or to provide a good supply of hot water ; if preferred, the copper may be in the bathroom (cp. figs. 10 and 11). In either case the copper should be arranged so that it can supply the hot water for the bath if necessary.

The form of the sink will vary : there are shallow sinks and deep sinks. The former cannot be used for washing up, but a basin or pan can be placed in the sink. The deep sink can itself be used for washing up, or a receptacle can be used in it. It can also be used for rinsing clothes, and is generally more useful than the shallow sink. The chief reason that the shallow sink is widely used is that of the cost ; the initial outlay is greater on the deep sink, and it is therefore more costly to replace if it is cracked or broken. The waste-pipe from the sink should, in a large house at any rate, be fitted with a grease-trap. This is, in effect, merely a chamber in which the grease in the waste water can rise to the top of the fluid and be removed at frequent intervals.

Sink-pipes should not get blocked up nor have a disagreeable smell, even in hot weather, nor is any deodorant or disinfect-ant needed, if proper care and attention are given. The waste water from the first washing of plates, dishes, etc., should be poured through the sanitary basket, which should be found in every household. This holds back the large particles, which can be removed and thrown into the waste-pail or bin. When waste-pipes are blocked it is nearly always due to carelessness ; either large shreds from the swabs used for washing up and cleaning, or pieces of soap, are thrown down the sink with dirty water—that is, the sanitary basket is not used. Hot fat is sometimes thrown away, when it should be collected, and it then cools in the pipe, or by some other careless act the sink is allowed to become blocked. If the sanitary basket is always used and kept clean, and the sink itself and any other receptacle used for washing up

are also kept clean, both outside and inside, there will be no smell at all from the sink. This only arises when decomposition is in progress, and means that an accumulation of putrescible material has been allowed.

The sink should have a supply of both cold and hot water, which last may be obtained either from the kitchen-range or from the copper. A good supply of hot water is essential for proper cleanliness, and the unfortunate housewife who may be condemned to wash up numerous plates and dishes with hot water obtained only from a small kettle expends unnecessary labour and will find it difficult to produce satisfactory results. A good supply of hot water must be regarded as a requisite of life, and a plentiful supply of cold water is, of course, necessary.

It is convenient for the bathroom to be near the kitchen or scullery on account of the hot water supply. There are differences of opinion as to the necessity of providing bathrooms in all working-class dwellings. There is no question that personal cleanliness can be maintained without a bath, but at the same time it is greatly facilitated by being able to wash the whole body at one time. In addition, there are other aspects of a bath which are dealt with in Chapter VII. It is very generally agreed that bathrooms should be available in any satisfactory new house. It is not enough to provide merely a bath in the scullery, as has frequently been done. The bath in the past was often fixed without proper hot and cold water supply and sometimes without drainage. Over it was a table-top or shelf hinged to the wall, which could be lowered or raised at will. The bath was perhaps in a draught between the window and the door, and little, if any, privacy obtainable. It can hardly be wondered at that, in the circumstances, the bath was more often used as a store cupboard than as a bath, especially if the house was deficient in storage accommodation—a not unusual condition. The bathroom must be private, and adequate facilities for bathing provided.

Sanitary arrangements are of great importance, and are usually placed in proximity to the bathroom. The object

of this is to economize piping, since both require waste-pipes, and the plumbing work is reduced by keeping the waste-pipes near one another, although the systems must be kept separate till they enter the main drain.

The only satisfactory system in a town is the water-carriage system. This needs a plentiful water-supply, but in the long run is probably no more expensive than any other system. The excreta must be dealt with in some way or other, since they may not be passed untreated into a river. The only clean hygienic way of dealing with them is to remove them as soon as may be from the premises. The water-carriage system conveys them direct to sewage works of one kind or another, where the treatment used renders the whole innocuous. In the country this method cannot be used and the earth-closet has already been described.

Where the excreta are not removed at once the " conservancy system " is employed ; some forms of conservancy are worse than others, but all are unsatisfactory and should not be tolerated in a town. The two chief forms are the privy and the pail closet. The privy is the worse of the two, and it is surprising that it should have been allowed to persist up to the present time. In general it is combined with a midden, or ash-place ; the theory apparently having been that the ashes could be used as covering for the excreta. A shed is usually provided with a partition extending inside from the top angle of the roof to within some inches or rather more of the floor ; this last is of concrete. On one side of the partition a seat is provided and on the other the domestic refuse is collected. Both sides of the shed have doors, the one for the closet, and on the other side usually two doors, a large lower one and a small upper one. The lower one is for the dustman when he comes to remove the refuse, and the upper one for the housewife.

Even under good conditions the arrangement would be unhygienic, as in effect it amounts to an accumulation of excreta on the one side and of domestic refuse on the other, there being little or no contact between the two. If these places were emptied frequently the evil

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would be reduced; but unfortunately, owing to their size, this is not absolutely necessary, and in some places they are emptied as seldom as every six weeks or even three months. During the intervals decomposition and the flies work their will, with the result that the air is nearly always vitiated and malodorous, and in the warm weather the flies render life in the adjoining houses almost intolerable.

It is difficult to describe at all accurately the position of the occupants of houses near a privy midden in warm weather. The smell is nauseating and the flies ubiquitous. The housewife cannot by any number of fly-papers keep her walls and furniture free from them, and everything is soiled almost as soon as it has been cleaned. They alight in numbers everywhere, even on the sleeping infant, and of course on any kind of foodstuff lying in any accessible place. These flies come direct from the privy, where they have been bred, and their legs and bodies are laden with the bacteria among which they have lived. In warm weather in this country the fly goes through all its stages from the egg to the insect in about ten days, although this may be shorter and in cool weather is longer. If flies are to be prevented from breeding, no rubbish should be left for more than seven days, in order to avoid giving time for the eggs to develop. The whole is well demonstrated in the picture of which fig. 14 is a copy.

There is no doubt that these insanitary arrangements, which are still common in the North of England, are productive of much sickness, especially among infants; but these are not the only persons concerned. The general health of the whole family cannot fail to be affected. There are other practical points about these privy middens which add to their general objectionableness, but enough will have been said to show how undesirable they are from the hygienic and domestic aspects.

The only advantage of pail closets is that, being smaller, they must of necessity be emptied more frequently; but they are thoroughly insanitary and require to be abolished.

The insanitary conditions which arise from arrangements such as these are shown in the accompanying figs. 15 and 16.
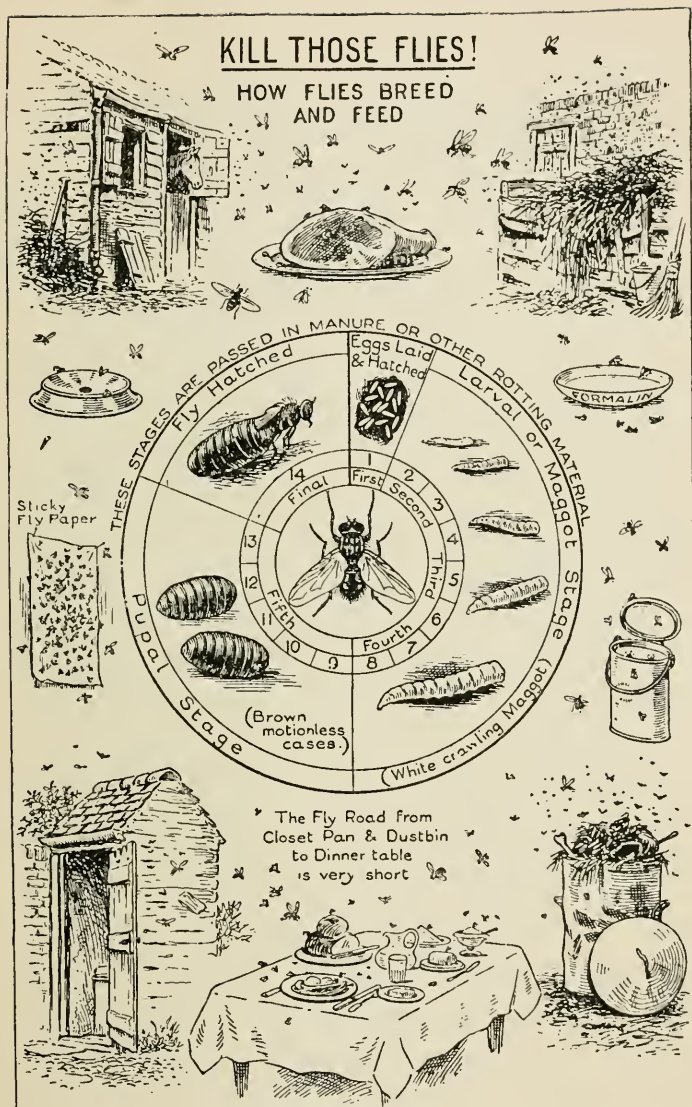
Fig. 14.—Poster showing the breeding of flies; their breeding grounds
and the way in which contamination is carried by flies.
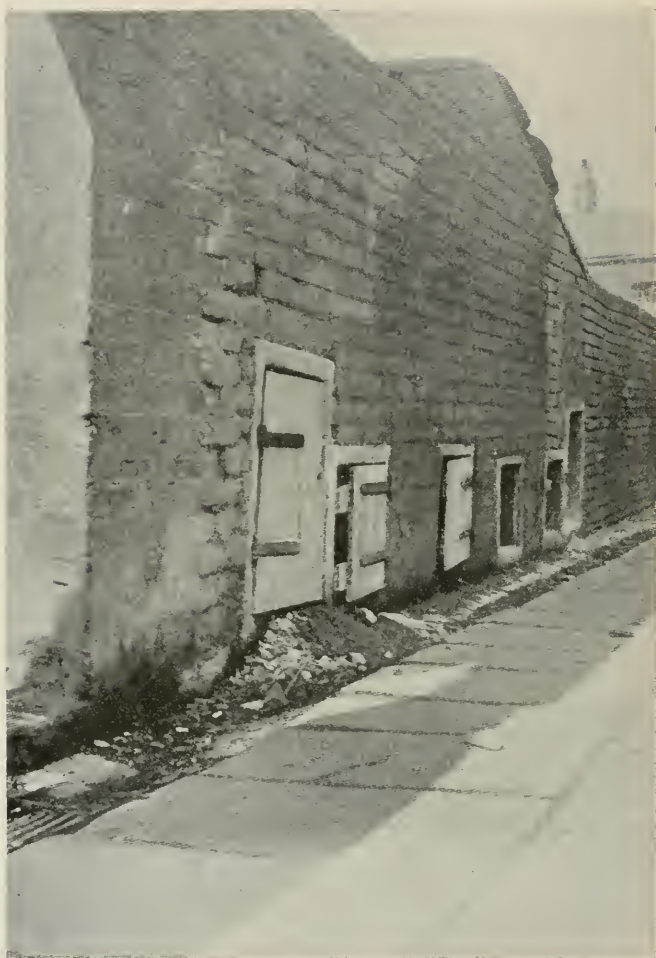
FIG. 15.—Middens in the North of England. Note the heap of refuse and the general condition of the doors.
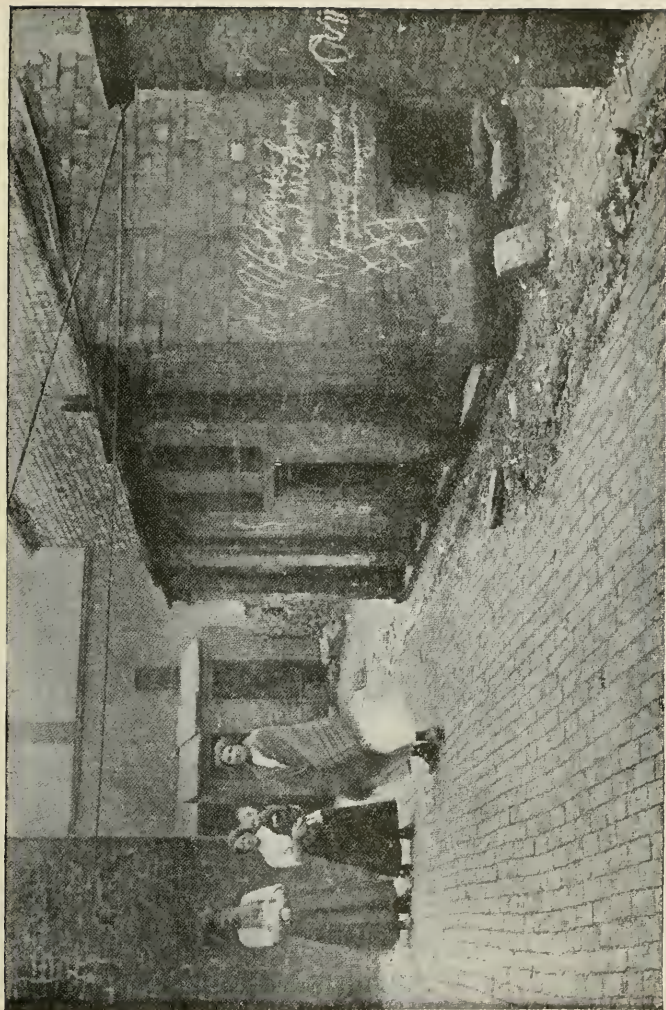
Fig. 16.—An insanitary yard. Note the pail-closet in the back of the yard, with its open door, and the middens in the foreground.

The waste-water closet is used in some districts, but is not satisfactory. It was believed that it would effect a great economy of water. The waste water from the house is carried by pipes into a receptacle which is balanced so that, when full to a certain level, it tips over, discharging its contents into another pipe which enters the side of the closet-pan, and the water flushes out the trap below the pan. The trouble is that the upper part of the pan gets soiled and thoroughly disagreeable and the pieces often allowed to run away in the waste water tend to block the trap of the closet. Thus, they often require attention, and sanitary inspectors state that the amount of water used in unblocking is in the aggregate probably as great as would be used by a proper water-carriage system. In spite of these drawbacks, some localities still adhere to this form of closet.

Domestic hygiene and the comfort of the home are closely connected with the disposal of refuse, as well as the general health of the inhabitants. The water-closet alone can be regarded as satisfactory in a town, and the refuse should be collected frequently from a good form of bin. The closet may be inside or outside the house, and may be on the ground-floor or upstairs, according to the arrangement of the plans. It should have through ventilation with a window on to the outer air—that is to say, it must not ventilate into the house and should not be in the centre of the house even if there is a ventilating shaft leading up from it. This last arrangement is not uncommon in old good-class houses. The window should not be near the larder, and the whole should if possible not be too near the living-rooms. Sometimes the w.c. is placed in the bathroom, but this has disadvantages for all but a very small family. The pan should be of porcelain and should not be boarded round, free access for cleaning being most desirable. Details as to the forms of closets can be found in text-books on general hygiene.

The place for coals should be accessible both to the coal-man and to the housewife, and a cupboard for brooms, etc., is almost essential. The bedrooms will be upstairs and

should, as already stated, be three in number when there is a mixed family.

It is important that the staircase should be well lighted. The stairs should not wind, if possible, and should be of sufficient breadth and not too steep. The Ministry of Health lays down the requirements of not less than nine inches for the tread, and a rise of not more than seven and a half inches for each stair.

The other requirements are dealt with in the next chapter.

CHAPTER IV

ADEQUATE provision for the storage of food is an essential for any house which is to be regarded as conforming to standards of hygienic needs. The far-reaching ill effects on the health of the family are not always appreciated, and it seems advisable to go into the position somewhat carefully.

There should be a larder for the storage of perishable foods, and a cupboard elsewhere for keeping dry stores. The larder should have a north aspect if possible, and, failing that, east, but not west and certainly not south. It needs to be cool and not exposed to the sun ; hence the north is preferable, but the east is next best. It should have a stone or brick floor, and if possible the shelves should be of stone or slate. Good ventilation is essential and the currents of air should pass right through the larder. The door must fit well so as to prevent the entrance of flies either under it or through crannies elsewhere. Some ventilating place is desirable in the door, and ventilating grating of various kinds can be fitted into it and into the lower parts of the wall so as to secure passage of air in the lower portions of the larder. The window must be of sufficient size ; all the openings for light or ventilation either by door, window, or grating must either be filled in with perforated metal sheets or be covered with gauze or muslin, so as to prevent the entrance of flies or other insects, or of dust and debris.

Frames upon which muslin can be stretched, can be made for fitting in to the ventilating spaces as soon as the weather becomes warm, or they can be kept in position all the year round. It must be remembered that the gauze will soon get dirty and must be cleaned as often as may be required. If the larder is not really fly-proof it will be necessary to

cover up all the food, either with fine wire covers or with muzlin or gauze supported on a framework, under which the food can be placed.

Dampness is undesirable in a larder, and trees, if planted near it, should not be so close as to drip on to it or keep the walls moist. Food does not keep well in a damp atmosphere, and moulds grow readily. The housewife has to contend against bacteria at all times of the year, but in winter they multiply more slowly than in the warmth of summer, so that their presence is less noticeable. Damp weather keeps down the dust, so that there are fewer bacteria in the air ; but a damp larder encourages the growth of moulds, the spores of which are found almost everywhere.

The larder is not suitable for storing dry groceries, for which another place should be available. This should preferably be in a position where it is dry and not too warm. It does not need to have any special arrangements for ventilation. It will be convenient for the housewife if this is placed either in or near the kitchen, so that she has not far to go for her stores. The modern kitchen cabinets are in effect small store-rooms and contain spaces for the commoner articles needed for daily use. These cabinets usually have a hinged or sliding shelf on which a good deal of the preparation of the food can be carried out, such as the mixing and rolling of pastry, and are undoubtedly convenient although somewhat costly at the present time.

If there is no larder the housewife is labouring under very serious disadvantages. She has no place in which perishable foods can be stored before cooking, so that she must purchase only when she wants to cook. Again, she has no suitable place to store the food which is left over after the meal. It will not keep good very long in the hot air of the kitchen, and the tendency will be to buy just enough for the one occasion. This means that fresh food must be purchased each day, involving a good deal of trouble both in the purchasing and in the cooking. It is, moreover, usually a good deal more expensive than buying in larger quantities, and keeping some over for use on the next or

even on the following day. Made-up dishes are difficult
to arrange in the absence of any place in which to store
food, so that variety of menu is less likely to be found than
where storage accommodation is present.

The visitor entering the house of some of the poorer work-
ing people will not infrequently see the remains of food left
out on the table in the kitchen exposed to the dust and dirt
and flies. Her first impulse will be mentally to condemn
the housewife as careless and extravagant. But inquiry
may show that there is literally no cool place for storage
and that the only cupboard is adjacent to the kitchen
fire. Doubtless with ingenuity and determination some
sort of place can be contrived. But it is hardly fair to
expect a housewife, who perhaps has never known the
advantages of proper facilities for storage either in the
home of her childhood or after marriage, to be very ener-
getic in providing herself with such accommodation. She
has accepted its absence as a part of the scheme of life.
Inevitably she tends to buy ready-cooked food or tinned
goods. These provide her with variety of food and at little
trouble. They may be more expensive, but will probably
not cost much more than she would need to spend on fresh
purchases every day, although of course much less nourish-
ing. Those who deplore the popularity of the fried fish and
chip shops and the ready-cooked meat shops would do well
to make inquiries into the facilities for storage and even for
cooking in the houses of those who patronize the shops.

In many houses the only cupboard is built into the wall at
the side of the kitchen chimney. Here the temperature is
continually kept high by the hot air from the fire. Dry
goods like sugar and flour can be kept for a time in these
cupboards, but perishable goods will not keep long in a warm
atmosphere. The absence of storage will therefore fre-
quently lead to an unsuitable dietary. Good hot meals
properly served will probably be a Sunday luxury, and the
rest of the week, the family, except perhaps the husband,
will feed on pieces, or on cooked or tinned foods, warmed up
for the occasion, and probably rendered palatable with

pickles or vinegar. A nourishing, well-cooked, and varied menu under the conditions described is a matter of such difficulty as to daunt all but the exceptional housewife. The casual meal made on a badly balanced diet will too frequently be provided in houses where storage facilities are lacking. It is not suggested that the provision of storage facilities would at once produce a suitable diet, but generations brought up in houses where the housewife works at a disadvantage cannot suddenly change their habits. This does not render it any less necessary to improve the conditions which are unsatisfactory.

It is impossible to say how much of the malnutrition and ill-health found among the poorer working classes is due to any one special factor ; there can be little doubt that the methods of feeding are often one of the causes, and this depends not a little on the methods of storage which are available. In the plans shown on figs. 10, 11, and 12 the larders are well arranged and are on the north side of the house, whether the aspect of the house be north or south. A dry storage cupboard is also arranged.

The heating of the house, its supply of hot water, and the lighting, are closely bound up together, and at the present time, with the high cost of fuel, is à subject of much importance.

In the country there will be little choice. The house must be heated by either coal or wood, as there will probably not be a gas supply. The lighting will be with oil-lamps. Coal is a wasteful fuel, and should, strictly speaking, not be used untreated as a fuel. Coke has had too much combustible material removed to be suitable as the sole fuel in an ordinary open fire. But it is possible to remove valuable material from the coal and yet leave a fuel which would burn in an ordinary range or grate. In Chapter VI the detrimental effect of the coal-tar products which are not consumed in the domestic fire are mentioned. The modern fire-brick grate, with the sides and back all in one piece of the material, is a great improvement on the old metal grate from the point of view of heating a room. It absorbs the heat and gives it off

again to the room, less heat passing up the chimney into the outer air. In towns, gas is usually available and is now installed in most houses. Until other fuel is available, however, coal will need to be used in country houses. There should be a coal range in the kitchen and small fireplaces in the parlour and in one at least of the bedrooms. The kitchen-range should have a boiler connected with it, which will take hot water to the bath and to the scullery sink. As already mentioned, the copper should be arranged to supply hot water direct to the bath, if desired.

A good deal will depend on the kind of range which is fixed. Some ranges are more economical than others, but there is waste of heat in the majority of ranges in use. Any lengthy description of ranges would be out of place here, but a few points may be mentioned. The flues carry away from the fire-box the hot air which is used to heat the oven and the boiler. In passing through the flues to the chimney itself soot and particles carried up from the fire by the hot air are deposited. This reduces the amount of soot in the air escaping from the chimney, but means that the flues must be cleaned out at frequent intervals. If the flues are allowed to become choked with soot the ovens and boiler will not get heated, being separated from the hot air by layers of soot. It has been calculated [1] that at least 6 per cent. of the coal burnt in domestic fireplaces escapes unconsumed into the air as soot. The Coal Mines Department gives the figure for coal burnt for domestic purposes as 40½ million tons per annum, so that nearly 2½ million tons of soot " escape into and pollute the atmosphere every year from domestic fireplaces alone."

It is hardly possible to calculate the amount of damage done by the soot and fumes, but there can be little doubt that it has a very destructive effect on buildings, and that it adds greatly to the upkeep necessary for private houses in the way of redecoration. Further, the additional cost per week per household for fuel and washing material in a smoky town

[1] Interim Report of the Committee on Smoke and Noxious Vapours Abatement, Cmd. 755, 1920, p. 1.

has been estimated. The figures show that the cost of these in Manchester, as compared with Harrogate, is $7\frac{1}{2}d$. per week higher in Manchester, thus adding a charge of over £290,000 per annum to the cost of personal cleanliness. Its effect on health is difficult to estimate, but there can be little doubt that it is considerable and very detrimental (cp. Chapter VI).

If, as is common, the range is fitted into the wall, a great deal of the heat is used in warming the wall and adjacent parts. This may be desirable up to a point, but the loss of heat may be excessive with badly constructed ranges. There are some small ranges which stand in the room, and which are economical both for cooking and for heating the room. Oil-ovens are now sold, which are preferable for summer weather, as they can more readily be turned on just for the period required for cooking. They do not, however, provide a supply of hot water.

In towns gas or electricity should be used for heating as far as possible. The main difficulty is the cost. If a fire is required most of the day a coal fire is a good deal cheaper than gas, at present prices. Much, of course, depends upon the housewife. If the gas is carefully used the saving of labour and the absence of ash-dust and soot may be regarded as in some measure meeting the additional cost. Then, again, some coal-ranges burn large quantities of coal, and gas would probably be cheaper to install. Both gas and coal burn up oxygen, and it is essential that the hot air from the fire should escape up the chimney and give rise to incoming currents of air so as to effect the necessary ventilation (cp. Chapter V). A gas-fire must be fitted to a flue just as a coal-fire must be, but it needs a smaller and less expensive one. The properly fitted gas-fire is very satisfactory both for warming and ventilating, but if required for many hours it is unfortunately more costly than a coal-fire. Cooking by gas, if carefully carried out, is hardly more expensive than using a coal-fire for cooking alone, as in the summer. The difficulty arises over the hot water supply. Gas is expensive to use for merely heating water

except by means of a geyser. The domestic saucepan boiling over a gas-burner is very wasteful. About 60–70 per cent. of the heat available is lost and only about 30–40 per cent. is taken up for the boiling of the water. A geyser is more economical, the heat loss being only some 20–30 per cent. as against the above 70–80 per cent.[1] A copper burning coal, or preferably coke, would be an economy where gas is used as the main fuel, and a geyser is not available.

There can be little doubt that electricity is the best means of heating. Unfortunately, at present in most areas its cost is prohibitive for all but the wealthy. Its installation for power as required for heating, in already existing houses, is an initial not inconsiderable expense, and the further cost of the electricity itself is, in most places, many times more expensive than gas. The saving in redecorating, etc., does not at present counter-balance the additional current charges.[2] Doubtless in years to come electricity will be developed and its cost reduced so that it will be more readily available.

For lighting purposes electricity should be used whenever possible : it is not expensive if carefully used, and saves much expense in redecorating, etc., as it gives off no fumes or dirt. It is very widely installed at the present time in many towns. Gas burns up a large amount of oxygen and vitiates the atmosphere of a room. The incandescent mantles are very liable to break if badly treated, and add to the expense of the lighting.

There are other methods of lighting, with acetylene, or petrol vapour, which are very suitable for installation in country houses of fair size. But electricity can also be manufactured by a small suitable engine, which last can be used for other purposes as well, especially for pumping water.

Central heating, either for warming or for the general supply of hot water, is excellent in large houses, and might be

[1] *Applied Chemistry*, Tinkler and Masters, pp. 228–30.
[2] The cost per unit of electricity varies widely in different and even in adjoining areas, so that no figures can be quoted which would be correct for more than the area concerned.

carried out in housing schemes. It presents little difficulty as regards installations, but has a fairly high initial cost, and the adjustment of the running expenses, if many separate houses are supplied, would probably present some difficulty. On the other hand, difficulties can usually be overcome, and a central supply of hot water would be a step in the direction of saving labour, and presumably of fuel. It would be much appreciated by the housewife.

CHAPTER V

THE dweller in the country who works during a large part of the day in the open air hardly realizes the need for fresh air for the maintenance of bodily health. He is often glad to get into shelter from the storms of rain and wind, and is apt to wish for rather less air. The town dweller, on the other hand, whose life is in great measure spent within walls of either a house or an office or factory, has urgent need of more fresh air than is often available in the course of his daily work.

The healthiest life is an out-of-door life. Had there been any need of proof the war has supplied abundant evidence. Every one knows of the intense exposure to cold and to all the inclemencies of the weather suffered by the armies in the trenches during the winter. Yet their general health was good apart from troubles arising from the difficulty of changing clothes and boots. The pale office boy improved out of all recognition when given plenty of fresh air and exercise and good food. The girls who went to work on the land underwent similar transformations when the first effects of the unaccustomed life and work wore off, and the muscles became better able to cope with the work required of them.

Both man and animals require protection from the extremes of weather, for reasons which will be discussed in this chapter. The present state of social life, where large numbers of people are aggregated in towns, conduces to habits and conditions of life where the body suffers from lack of the health-inducing influences of fresh air.

For many years past there has been much talk of the need for oxygen and of the detrimental effects of carbon dioxide. While both these are important, especially the former, it

would seem, from the researches of L. Hill,[1] and others,
that these two matters should not alone receive attention
but that there are other points of almost equal importance
for health.   These points will, it is hoped, be most simply
explained by considering, first of all, the effects of out-door air
on the body before dealing with the more complex conditions
of indoor life.

Most people have been taught that the air is composed
primarily of two kinds of gases, oxygen and nitrogen,
together with a variable amount of water-vapour ; that the
nitrogen forms about four-fifths of the whole atmosphere,
and that it has no specific action, being present as a diluent.
Roughly, therefore, there is about 20 per cent. of oxygen
in the atmosphere.   In addition, there are small amounts of
carbon dioxide—about 4 parts per 10,000, and traces of
other rare gases.   The existing respiratory apparatus of man
and animals cannot tolerate an atmosphere where the oxygen
is present in considerably higher proportion than one-fifth.
The carbon dioxide, although present in such small amounts,
is of the utmost importance for life.   It is, in a sense, both a
waste product and a food.   It is ordinarily regarded as a
waste product in man and animals, because it is given off
from the body in the expired air from the lungs, in larger
quantities than it is taken in.   It has just been mentioned
that this gas is found in the proportion of about 4 parts
per 10,000 in the air, but in expired air a common average
figure is 6 parts per 10,000.   Further, it is well known that
carbon dioxide (CO_2) and water (H_2O) are constant end
products of metabolism, not being broken down any further
by the body.   Both these substances are got rid of continu-
ally in the expired air.   The CO_2 is carried from the tissues
to the lungs in the venous blood, and is there liberated as a
gas, the water passing off as water-vapour.   The body, how-
ever, needs some CO_2 to act as a balancing agent for the re-
action of the blood, and normally only the excess is passed

[1] Reports Nos. 32 and 52 of the Medical Research Council, *The Science
of Ventilation and Open-air Treatment*, published by H.M. Stationery
Office.

4

out in the lungs. The deep breathing induced by exercise is the response of the body to the need of getting rid of an increased formation of CO_2 (cp. also p. 136). On the other hand, if very deep breathing is performed, either deliberately or from a decrease of oxygen in the air breathed, too much carbon dioxide may be washed out, giving rise, if persisted in, to considerable disturbance of the circulation and respiration. In such a case, breathing air with an addition of 1–2 per cent. CO_2 relieves the condition. Carbon dioxide is, therefore, essential to life in certain proportions, but too much of it is injurious. Plants take up carbon dioxide during the day, under the influence of sunlight, and under this influence the carbon dioxide combines with the water in the plant leaves and formic acid is produced, which is then converted into sugar and ultimately into starch, acting as a food for the plant, and in many cases also for man and animals. At night plants give off CO_2 as a waste product of their metabolism.

It has long been realized that the three gases, oxygen, nitrogen, and carbon dioxide were necessary to life, but it would seem that too much stress has been laid on these as chemical substances, and that too little attention has been paid to the other properties of air. Nearly every one realizes the revivifying effects of sea or of mountain air, and of the added power of exercise and work experienced under their influence. The smell at the sea-side, often called the smell of ozone, is in reality due to decaying seaweed and has no health-giving properties. The real health-giving properties of sea and mountain air are due to the effect of the breeze on the skin of the body. It has been shown that air blown on the skin produces decided effects, which differ in their intensity with the temperature, both of the air and of the skin, and also with the velocity of the air.

The body is always producing heat in the course of its metabolism, and this heat is ordinarily got rid of by means of the vaporization of water from both skin and lungs. Air acts both as a cooling agent and as a stimulus. On a warm day, or after exertion, when the body wants to get

rid of the excess heat formed, a gentle breeze, by increasing the rate of cooling, aids in the ventilation of the body and hastens the removal of the heat. This is accomplished by blowing gently through the clothing and hastening the evaporation of the moisture. Also it acts as a stimulus to the whole nervous system, more especially on the exposed parts, such as the face and hands. If, however, the breeze be cold it will tend to constrict the vessels of the skin.

When a person comes out into the open air for exercise or for definite work he will probably (except in very hot weather) feel that the air is cold, and the effect of the air will be to induce constriction of the vessels of the skin. As he works, the heat produced by the muscles brings about a dilatation of the skin-vessels (cp. p. 135). And the heat given off is removed by the formation of water-vapour and by the drying up of the water-vapour by the current of air. If the air be already heavily laden with water its drying effect will be reduced, and its cooling effect also; hence the greater effort of walking on a damp day or in a damp climate, especially if there is little wind.

If the air be very cold and the breeze strong the heat production of the body may not be able to keep pace with that removed by the cold wind ; on such a day it may be felt to be too cold to work out-of-doors. That the strength of the wind is more important than actual temperature is well known from the experiences of Arctic and Antarctic explorers. In those regions, although the temperature may be many degrees below freezing-point, those concerned may feel very hot on a still day, when taking exercise, but may be unable to go out in the same temperature, as shown by the ordinary thermometer, if a wind is blowing. Again, when the work done causes production of heat in sufficient amounts to induce comfort in any particular strength of wind, the individual will soon feel cold and chilly on standing in the wind after work has been stopped. Heat is being removed all the time, but when no work is done insufficient heat is being produced to counterbalance that used up by evaporation in the wind. Hill considers that

sensations of heat and cold are all relative, and that feelings of warmth or chilliness depend entirely upon the difference of temperature between the air near the skin and that of the blood.

Hill [1] says : " The nerve endings of the epidermis, and those deep in the dermis, may be compared to thermo-junctions ; by sensing the difference between the surface temperature and blood heat, they produce feelings of chilliness or warmth. If, after the body has been heated by hard exercise, say to 102° F., one rests in a draught, the blood temperature is still at the higher level, while the cutaneous surface cools rapidly, vaso-constriction taking place, and, the moist skin continuing to evaporate, sensations of chilliness then result.

" The rate of evaporation from the skin and the moistness of its surface, the contact with water particles, rain, chill mist, warm steam, profoundly influence our sensations of comfort or discomfort. Adaptation and indifference to cold comes about by training, e.g. the naked Terra del Fuegians, the bathers who break the ice for a swim in the Serpentine, the soldier returning from the front who does not even feel the draught which makes the sedentary worker shut the window.

" The evaporative power of the atmosphere has a far-reaching effect, not only on the comfort of the skin, but on the respiratory membrane, the absorption of water from the gut, and the renal secretion.

" The ceaseless variation in the rate of cooling, evaporation, absorption of radiant energy, as in outdoor conditions, relieves us from monotony, stimulates tone and metabolism. Indoors the conditions are generally uniform, monotonous, and unstimulating. In closed, artificially heated rooms the cooling and evaporative powers are very greatly reduced by the lack of the vastly freer ventilation which pertains out of doors, even on calm days."

The effect of wind and sun is to stimulate the sensory endings and to improve the whole tone of the body. All stimuli, if applied too frequently, will give rise to fatigue. The worker accustomed to an out-of-door life responds to

[1] Report cited, vol. i, p. 11.

the stimuli with a less degree of intensity than a sedentary worker. These feel the effects of outdoor conditions more keenly than the outdoor worker, and must harden themselves gradually on taking to an outdoor life, or on a holiday.

The rate of evaporation from the body appears to be a most important matter. Some degree of evaporation is essential in order to remove the heat formed, even if no exercise be taken. This rate depends not only on the relative temperatures of the body and of the air, but also upon the velocity of the wind and upon the amount of water-vapour present in the atmosphere at the time. Evidently both these factors can be controlled by clothing, and much evidence on this has already been collected and many experiments carried out by Hill and others, of which some account will be found on pp. 91–96 of this book.

In order to determine the effect of wind and of other factors on the rate of cooling of the body, Hill has invented a special thermometer, which he calls the kata-thermometer. This instrument is calibrated to show its own rate of cooling at a temperature approximately that of the body, and not an absolute temperature. It can be used either naked or covered with materials of various kinds, in single or in several layers. The results are expressed in the heat lost per second per square centimetre of surface of the thermometer bulb. The unit of heat taken is a millicalorie. The figures obtained represent, therefore, the number of millicalories lost per square centimetre of surface under the varying conditions of study. These figures differ widely according as the bulb is left naked or covered with a piece of material. They also differ as to the nature of the material used, and whether it is wet or dry. A wet covering gives a higher rate of cooling owing to the removal of heat in the vaporization of the water—that is, in the drying of the covering. This question of vaporization and its opposite, condensation, plays an important part in determining sensations of heat and cold. For example, on entering a room after exercise in the open dry air, if the air of the room be warm and humid, moisture will condense on to the clothing. In condensing

it gives up its heat of vaporization and imparts a feeling of warmth. If the air becomes drier or the person again goes out into dry air, a sensation of cold is experienced owing to the heat removed by the evaporation of the water.[1]

Hill[2] says: " There can be a sensation of chilliness in a calm mist, and quite a low rate of cooling of the body surface, and a sensation of warmth accompanying sweating on a warm day and a high rate of heat loss. *It is the varying differences between the surface and the deeper blood temperature which controls the sensations.*"

The presence or absence of the radiant heat of the sun also makes a great deal of difference in a climate like that of England.

It is impossible to go more deeply into the importance of the cooling power of the air and the effect of sunshine. It is hoped, however, that enough has been said to emphasize the great value of fresh air, not merely for the face and lungs, but for the body generally. All parts of the body require ventilation, and the clothing must be adjusted to meet the needs both of the weather and of the individual. At the same time the power of adaptation of the body, through the contraction or dilatation of the vessels of the skin, should be borne in mind. The town-dweller, whose body is usually in a poor state of tone, will require greater care than the outdoor worker, if discomfort and chills are to be avoided.

Chills and colds are rare among those who work out-of-doors, even in rigorous weather. They are the common lot of the enervated town-dweller, who lives in more or less vitiated atmospheres, liable to infection from dust or dirt and from other persons. The effects of dust and dirt are considered separately in Chapter VI.

So far only the ventilation of the body by means of air has been considered. This in itself is not very simple, owing to the number of varying conditions which are found. The

[1] Vapour, in condensing to water, gives up its heat of vaporization, amounting to five hundred and eighty calories per gramme ; the same amount of heat must be obtained from the surrounding air if the water again becomes steam.

[2] Report to M.R.C., No. 32, p. 107.

question is rendered more complicated when indoor ventilation has to be dealt with. The need for the renewal of the air is very generally, although not universally, admitted, and it is necessary to discuss the methods of securing this, and the basis of the methods adopted.

It has long been realized that, when several persons are present in a room, the temperature of the room rises, owing to the warmth given off from their bodies. Also the air becomes stuffy and disagreeable, although this is less noticeable to those in the room than to someone coming in from outside. The change in the air has been attributed to various causes ; chiefly to the carbon dioxide given off, but also to less defined emanations, said to be given off in the breath and from the skin. Under this theory each person should have about 3,000 cubic feet of fresh air per hour—rather less if the work be sedentary, more if active. This is based on the assumption that CO_2 in the air should not exceed 6 parts per 10,000. As the air already contains 4 parts per 10,000, there is a margin only of 2 parts per 10,000 to allow for contamination from the breath. But an average person may be said to give off ·6 cubic feet of CO_2 in an hour, or ·2 in $\frac{1}{3}$ of an hour. An individual supplied with an air space of 1,000 cubic feet would vitiate the air to the extent of ·6 per parts 1,000 in the hour, or 6 parts per 10,000. But there is a margin only of 2 parts per 10,000— that is to say, the air must be changed three times in the hour if this standard is adopted. In actual practice this is an impossible standard to adopt, and the air-space found or demanded under different conditions varies widely, as shown in the following figures :

	Cu. ft.
Poor law infirmaries, according to regulation . .	1,000
Soldier's ,, ,, ,, ,, . .	600
Pauper's dormitories ,, ,, ,, . .	300
Sick bay, navy	250
Average mess deck, navy	150
Average cinema theatres, Birmingham . . .	140
Sleeping deck, " Dreadnought " class . . .	86
Soldier's military transport	80
Sleeping deck, " Formidable " class . . .	68
A crowded dug-out curtained against gas . .	3

(Medical Research Council Sp. Rpt. Ser. No. 52, p. 263.)

Hill and his collaborators have shown conclusively that the stuffiness and discomfort experienced are not due to the increase in carbon dioxide, and that the carbon dioxide content can be increased to even 3 per cent. or possibly more, without any sensation of distress, if other conditions are satisfactory. One of these is the movement of the air, another is the humidity, and the third is the temperature. Air may be complained of as being " bad " and " un-hygienic " when the CO_2 content is below the prescribed limit. Absence of air movement gives rise to a sensation of stuffiness ; there is no stimulus to the skin of the body, and the air will have little or no evaporative power. As a result of a vast number of experiments, Hill concludes that the figure for the cooling power as measured by the dry kata-thermometer should be not lower than 6, and that as measured by the wet " kata " not less than 18, and he thinks the figures should preferably be 7 and 20–30 respectively. " Higher cooling powers are comfortable if the feet are kept warm."

It is obvious that there will be wide variation in the con-ditions found. Among the large number of valuable data collected or obtained by him one investigation is perhaps of special interest and is worth quoting in full.

He says : " During the war rooms of the National Gallery were allocated to clerks engaged in auditing accounts. The galleries are high and lit by skylights, ventilated by small roof-openings, heated by steam-pipes laid in tunnels under the floor, these ventilated by gratings in the walls. There was ample space and no overcrowding. The conditions were such as to give a stagnant, monotonous atmosphere, and such readings on close days as dry kata cooling power 4·5, wet kata 16, dry bulb 73, wet bulb 63. In such stagnant air infectious colds were easily spread, the workers sitting close.

" The clerks worked from 9 a.m. to 1 p.m., and from 2 to 5.30–6 p.m., at the monotonous and trying occupation of auditing figures. There were no windows, and they could get no change of sight, no refreshing breeze. Ventilation was maintained only by convection. The complaints of want of ventilation were great. Clerks said there was no

oxygen, they could ' cut the air with a knife '—expressions provoked by the absence of visible ventilation, and based on the chemical theory of vitiated air. One girl, pale and anæmic, fanning herself, said she would like to tear open the skylights.

" The absences of these employees from ill-health were considerable and the economic waste arising therefrom great.

" The chemical purity of this atmosphere could not be assailed ; the carbon dioxide increase was insignificant. The hygienic expert called in found no cause for condemnation. The higher official marked the papers ' no action,' but the kata readings showed that the air had too low a cooling power and evaporative power. The working hours were too continuous and too long, and the work most monotonous. The girls travelled by warm, shut-up, crowded tube trains ; probably they took no active exercise at home." [1]

Many other similar investigations prove that it is the change of air, as shown by its cooling and evaporating power, which renders the atmosphere indoors pleasant or the reverse. The amount of change of air which is necessary for comfort will depend not only on the temperature of the room in relation to the air outside, but to the amount of work being done by the persons in the room. The greater the heat produced by the body, the higher the cooling power required for comfort. Very heavy work should be done in sheds where there is very free ventilation. Practical difficulty is also experienced by the varying ages and conditions of health of the occupants of the room or workshop. Old or debilitated people work less strenuously and produce less heat ; hence they require less cooling power in the air, and are afraid of draughts. Again, different amounts of clothing and of different thicknesses are worn by the several persons, which again alters the cooling power they require for comfort. It must be, however, remembered that thick clothing, unless light and allowing room for movement and space for ventilation, hampers the removal of water from the skin, and leads to lack of tone in the skin-vessels and

[1] Report to M.R.C., No. 52, pp. 259–60.

to a feeling of fatigue ; this arises from the insufficient evaporation of the sweat. There is also a greater risk of chill on leaving the heated atmosphere.

Hill's calculations of rates of metabolism observed by Cathcart show that, whereas a cooling power of 5–6, as registered by the dry katathermometer, may be sufficient at meal-times, roughly double the degree of cooling, or a kata figure of 10–11, will be desirable when scrubbing a floor.[1]

It is beyond the scope of this work to deal with the mechanical appliances for securing change of air in houses or institutions. It may, however, be pointed out that all devices for " natural " ventilation depend upon the difference in temperature between the air inside and outside. The warm air inside (warmed either by persons or by some form of heating, or by both) rises to the top of the room and seeks outlet. If there is a chimney, and the air is being warmed by a fire, the hot air from the fire will rise and draw in colder air from outside through all the available cracks and crannies, or through the window or door if open. Unless the doors and windows fit more tightly than is usually the case, a very considerable amount of fresh air is obtained through the cracks. Too often, however, the position of the inlets is badly adjusted, or the inflow may amount to a draught of cold air. Gusts of cold air entering at or near the floor level will keep the feet cold, and the head may be unduly warm. The feet should be kept warm and the head cool. A not inconsiderable amount of ventilation is obtained through the walls of the room or house. The total amount will depend upon the material used, upon the presence or absence of flues or crannies, upon the temperature on the two sides of the wall, upon the exposure to wind and other variables. No exact estimates are possible, as the factors involved are too variable. The thickness of the walls makes a great difference in the temperature of a room. The 9-inch wall of one brick thick used by jerry builders gives a cold

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[1] Cp. Hill, Sp. Rpt., Ser. 52, p. 262, and Cathcart, *Proc. Roy. Soc.*, January 31, 1920 ; *Energy Expenditure of Infantry Recruit*, H.M. Stat. Office, 1919.

house. The Ministry of Health requirements give a hollow space in the walls, which acts as a non-conducting layer, making the rooms warmer in winter and cooler in summer.

In the majority of rooms of moderate size, ventilation is adequately effected by the intelligent use of windows and door, coupled with an appropriate method of heating the room. For very large places such as schools and factories artificial ventilation may be required. By these systems air is forced in or sucked out by means of electrically-driven fans. Not infrequently, however, these fans are not well placed, and insufficient attention is bestowed on their working, to the discomfort of the workers and the detriment of their health. The great disadvantage of all systems of mechanical ventilation is the difficulty which arises when anything goes wrong with the machinery.

Where heavy work which causes sweating is undertaken the need for adequate cooling and evaporation is very great.

High or large rooms are more difficult to ventilate than low or small ones, and are more expensive to warm. The warm air rises, and the air of the rooms is, as it were, heated from above downwards—the higher the room, the more heat is required. Also, unless the windows reach to the level of the ceiling the air above the top of the windows will rarely, if ever, be changed. It was found that the ventilation in dug-outs, even where there were a number of people and gas curtains, was frequently quite sufficient to maintain a good degree of purity of atmosphere owing to the difference in temperature between the inside and the outer air.

Fresh air at night is very important, especially to those who do not work out of doors in the day-time. It must, however, be remembered that the ventilation of the body under the bedclothes is not effective, and sufficient ventilation of both bedding and night-clothes is required on arising.

It is necessary to be warm during sleep, but the value of a bath and good rubbing of the skin to give tone to the body after the night's rest will readily be appreciated (cp. Chap. XIII).

CHAPTER VI

IF everyone realised the harmfulness of dust and dirt we should be a healthier nation. It cannot be too often restated that dust and dirt mean bacteria, and these in their turn mean ill-health and disease. It is true that all bacteria do not cause disease, but it is impossible to tell without bacteriological examination whether those certain to be present are harmful or not. Again, it is probable that even harmless bacteria, if present in large numbers, can give rise to disturbances of health. It seems fairly evident that, if swallowed in their myriads, they give rise to gastric or intestinal irritation, although some authorities consider that this has not been clearly proved. Dust-laden air is well known to be harmful, and how far the irritation set up is due to the bacteria, and how much of it to the particles to which the bacteria are attached, is difficult to determine.

The pureness of country air, which is so healthy, is due in great part to the absence of dust and dirt. Town air is laden with bacteria attached to the particles of dust from the roads and of smoke from the houses and factories. The appearance of smoke is due to the presence of particles of carbon. On leaving the chimney these particles, no doubt, are relatively free from living bacteria, owing to the heat of the fire ; but they will soon become contaminated and bacteria-laden.

The formation of fog is closely bound up with the presence of impurities in the air. Air contains varying amounts of

water-vapour, which again is dependent on the temperature. The air may become saturated with water-vapour, after which point the water-vapour will condense into droplets and appear as mist or rain. The amount of water-vapour which the air can hold without condensation depends on the temperature. If the air be nearly saturated at any given temperature a relatively small drop in temperature may cause the air to be supersaturated for this new temperature, when droplets of water may form. If there is complete absence of dust, supersaturation may not necessarily produce condensation—that is, droplets [1] may not form, and hence a mist will not arise. This property of the atmosphere explains the prevalence of fogs in towns. Mists in the country are also due to changes of temperature of an atmosphere heavily laden with moisture. These changes of temperature will ordinarily be much greater in the clearer air of the country than in town air, yet fogs are worse in towns where many particles are present in the atmosphere.

There are many methods of estimating the number of particles—that is, the amount of dust present in the air ; great care must be taken if accurate results are to be obtained. Several methods involve drawing a known volume of air through some substance which will catch the particles, which are subsequently counted under the microscope by taking a small sample, or by weighing the amount of dust collected. The number of particles present has also been measured by comparing the intensities of fogs produced experimentally, by rarefying the air, and thus causing a deposit of moisture on each particle. The intensity is compared with suitable standards of dust-free air.

It will be valuable to study some of the results which have been obtained by these methods.

Using a method of applying the condensation of water

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[1] The formation or not of droplets in a supersaturated sample of dust-free air depends upon the degree of the expansion of the air in its saturated state. It can expand up to one and a quarter times its original size before condensation occurs.

round particles and counting them with a lens, Aitken [1] found the following number of particles in various places :

	No. per c.c.
Four feet from floor of room in which gas was burning	1,860,000
Near ceiling	5,470,000
Air above Bunsen flame	30,000,000
On the shore of Loch	205–4,000
At the top of Ben Nevis	335–473

In open air of London or Paris, many hundreds of thousands.

Palmer [2] obtained the following figures by another method :

	Particles counted per c. ft.[3]	Weight in grammes per million litres.
Out-of-doors, street level .	118,000	1·1
Wedworth, 10th floor .	72,000	0·3
Building, 58th floor . .	23,000	0·17
Business office . . .	128,000–172,000	0·2–0·4
Department store, basement	94,000–118,000	0·2–0·9
Pearl button factory . .	72,000–139,000	0·2
School luncheon-room (a) .	258,000	1·8
Ditto (b) . . .	97,000	0·3
Ditto (c) . . .	1,090,000	2·0
Marble-cutting shop (d) .	590,000–691,000	1·9–2·4
Subway platform . .	1,130,000–2,320,000	1·7–3·0
Iron grinding room . .	14,800,000–48,700,000	4·4–7·5
Hat fur factory. . .	435,000–701,000	1·9–4·7
Rag-sorting shop . .	215,000–568,000	7·9–3·3
Mattress-renovating shop .	1,530,000–7,140,000	2·4–22·2
Feather-drying with starch (e)	160,000–867,000	27·9–14·7

It cannot definitely be asserted that all these particles contain bacteria, but the following figures, taken from various authors, show that the correspondence is fairly close ; they

[1] *Nature*, March 1, 1888.

[2] *American Journal of Public Health*, 1916, 6, 1049.

[3] These figures must be multiplied roughly by 35 to convert into the number of dust particles per c. metre.

(a) 500–1,500 pupils present.

(b) Few present, windows open.

(c) Janitor sweeping.

(d) Compressed-air chisels used.

(e) Very hot, dry room ; feathers packed in starch are beaten by machinery to remove starch.

also show the effect of traffic and dry winds in vitiating the atmosphere :

	Bacteria per cubic metre.
Air in Salon at Paris, Saturday, showed . .	42,000
,, ,, ,, ,, ,, Sunday at 3 p.m. showed	3,240,000
,, ,, ,, ,, ,, ,, ,, 4 p.m. showed .	5,000,000

In a street in Paris the following figures were obtained :

	Bacteria per cubic metre.
8 a.m.	545
10 a.m.	2,300
12·0	9,600
2 p.m.	14,200
5 p.m.	20,800

In the air above a house staircase :

	Bacteria per cubic metre.
Before sweeping were found	750
After ten minutes' dry sweeping of carpet . .	410,000

Above stone staircase :

	Bacteria per cubic metre.
After dry sweeping were found	140,000
After wet sweeping were found	26,000

Underground station :

	Bacteria per cubic metre.
9 a.m. were found	410
11 a.m. were found	68,000
After dry sweeping of platform were found .	210,000

Graham Smith found three times as many bacteria at the base of the Clock Tower at Westminster as there were at the top.

The above figures could be multiplied, but they show abundantly the harmful condition of dust, and the desirability of keeping roads watered and of not sweeping without sprinkling with water. Dust must be removed, not merely stirred up and left to settle again, as is too often the case with dry sweeping or dusting. The old-fashioned

plan of sprinkling tea-leaves to catch the dust when sweeping had a sound hygienic basis, and should not be neglected. Dust may contain germs of tuberculosis, and bacteria from horse fæces will most probably be found in dust on the roads. The tubercle bacillus is extremely resistant to drying, and also to cold, and has been shown to survive all conditions of weather, at any rate, as found in countries with temperate climates. Bacteria are prevented from spreading by rain, but are aided by dry weather, as they are then conveyed in the dust. Summer diarrhœa in infants is always less prevalent in a wet summer than in a dry one, and the difference would appear not to be due entirely to difference of temperature.

Rain has a very cleansing effect on air. It carries down the dust and draws down the higher and purer strata of air. A rain- and wind-swept area is usually healthy, although it may not have a pleasant climate. Probably the relative good health of sea-side towns is largely due to the storms and sea-spray, which reduce the dust and purify the air. The death-rate of inland towns which are wind-swept owing to their position, as compared with neighbouring towns of similar nature, but lying in a valley, shows the gain in health experienced by the inhabitants of the wind- and rain-swept district.

The harmful effects of dust both out-of-doors and indoors has been abundantly shown. Out-of-doors it is easy to trace the effect on plant-life. The smoke contains tarry matter derived from the use of raw coal for fuel, and this falls on the leaves and chokes the apertures, preventing breathing, often to such an extent as to kill the plant. The dirt of leaves is well shown by the following photographs (see figs. 17 and 18) of holly and laurel leaves, which were growing in the grounds of Leeds University and were half-cleaned before photographing.

Further, a sooty atmosphere tends to be acid, and has been shown to prevent proper growth of grass and plants. Cohen and Ruston made elaborate analyses of the rain falling at Leeds and at Garforth, outside Leeds, and used

samples of the rain for watering grass. The effect is shown
in fig. 19. Further, water was prepared containing sulphuric
acid in proportions comparable to those found in the rains
concerned, and was used for watering grass-seeds. The
effects are shown in fig. 20.

Cohen analysed both the grass and the soil of the country
under consideration. He found that there was much re-
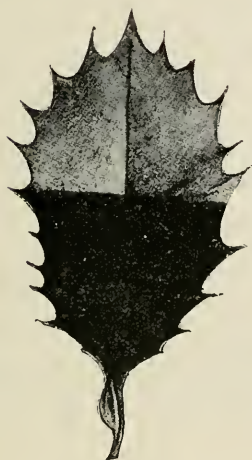

FIG. 17.—Holly-leaf from
Leeds University garden.
One half has been cleaned.

FIG. 18.—Laurel-leaf from
Leeds University garden.
One half has been cleaned.

duction of nitrogen and of salts in the grass itself, and that
the soil had a lower bacterial content, and, hence, a reduced
absorption power for oxygen.

Everyone is familiar with the difficulty of getting certain
plants to grow in towns, owing to the vitiated atmosphere.
It can hardly be supposed that the effect so marked on
plants is not also marked on the growth and development
of human beings.

The amount of soot and dirt estimated as being deposited

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per square mile in different towns and areas is of great interest.

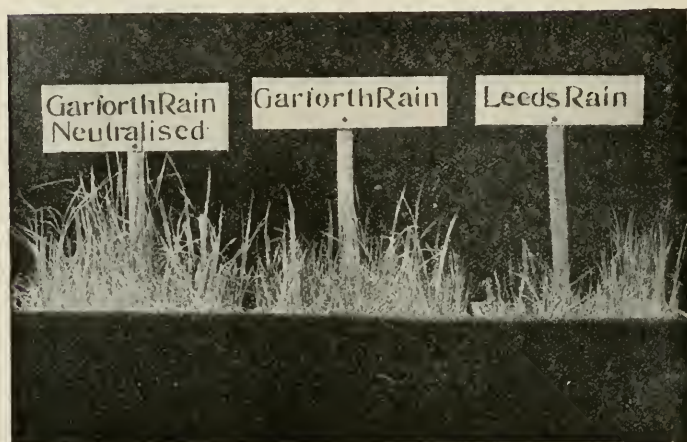|					Tons per square mile per annum.
London, Old Street, E.C.	.	.	.	.	650[1]
London, Buckingham Gate, S.W. .	.	.	.	500
Leeds, four square miles central area	.	.	.	190
Glasgow	.	.	.	.	.	.	.	1,330
Rochdale. 89 tons per month	.	.	.	.	1,068
Newcastle-on-Tyne. 53 tons per month	.	.	636
Malvern. 6½ tons per month	.	.	.	.	78

FIG. 19.—Showing the effect on the growth of grass of watering with rain-water, as shown on the labels.

Brend [2] regards the vitiated atmosphere as being probably the primary cause of infant mortality. He says : "Dirtiness of the air seems to be the one constant accompaniment of a high infant mortality : purity of atmosphere is the one great advantage which the agricultural labourer of Wiltshire, the Connaught peasant, and the poverty-stricken crofter of the Highlands enjoys over the resident in the town. In the opinion of the writer, a smoky and dirty atmosphere, as a cause of infant mortality, far transcends all other influences."

[1] The figures are from various sources.
[2] *Health and the State*, p. 87.

While it may not be possible altogether to endorse this view, there can be no manner of doubt that it is one of the influences militating against health, and hence against happiness. A condition of the atmosphere at Leeds is shown in fig. 21. The table on page 68 shows the effect of a foggy month on the death-rate from respiratory diseases in Glasgow.[1]

The general effect on health of cold, foggy weather is well known in all the out-patient departments of children's
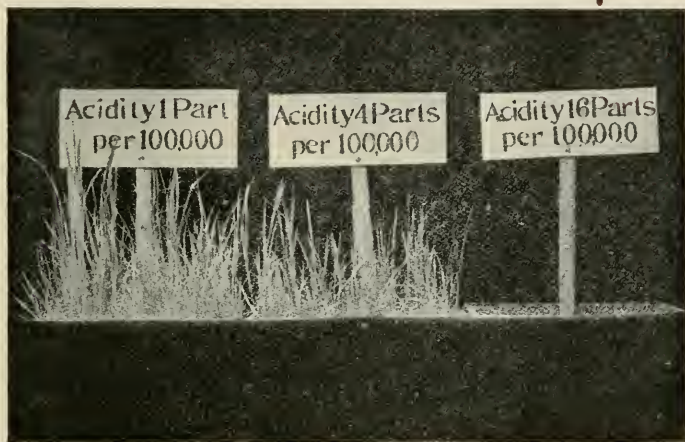

Fig. 20.—Showing the effect of watering with acidified water, as shown on the labels ; this should be compared with fig. 19.

hospitals. After some thirty-six hours of cold autumn or winter fog every physician knows that his out-patient department will be over-burdened with cases of bronchitis, some mild and some severe. With the return of better weather there is at once a reduction in the number of cases of respiratory trouble. Further, the figures for infant deaths from bronchitis and other respiratory troubles are higher in the industrial areas where the atmosphere is polluted than in those areas where the atmosphere is less vitiated.

[1] Report Intern. Smoke Abatement Exhibition, 1912 (quoted from M.R.C. Report, No. 52, p. 146).

1909–10.	Glasgow.		Seven other towns.		Mean city temp.	Weather conditions.
	No. of deaths.	Death-rate.	No. of Deaths.	Death-rate.		
October (weekly average) . . .	35	2·1	31	1·5	49·2°	Clear to dull.
Week ending Nov. 6	61	3·6	44	2·3	45·0°	Three days' fog.
,, ,, ,, 13	75	4·5	39	2·0	44·0°	Dull, slight fog.
,, ,, ,, 20	138	8·3	55	2·9	30·7°	Five days' dense fog.
,, ,, ,, 27	233	13·9	63	3·3	40·3°	Hazy.
,, ,, Dec. 4	171	10·2	93	4·8	42·3°	Hazy or wet.
,, ,, ,, 11	198	11·8	76	4·0	37·0°	Four days'fog
,, ,, ,, 18	137	8·2	78	4·0	38·5	Slight haze.
,, ,, ,, 25	95	5·7	76	4·0	31·9°	Slight fog and clear.
,, ,, Jan. 1	93	5·6	88	4·6	43·1°	Wet or clear. One day fog.

A very little consideration will show how this is brought about. Dirty material, soot and grime, is deposited everywhere ; the air carries it into the homes. The clothing is covered with it, also the face and hands. The average individual loses heart at the increased effort required to keep either the home or the person in a cleanly state. The furniture becomes grimy and the skin cannot be continually cleansed. Bacteria are prevalent and are being continuously inhaled. Children have a habit of fingering everything and of sucking their fingers afterwards, thus taking in extra doses. The mucous membrane becomes inflamed, giving rise to a cold or bronchitis, which is clearly likely to be worse when the particles are held in increased numbers in the air, as is the case in a fog.

The five towns having the highest infant mortality rates from respiratory diseases for the years 1907–10 were [1] :

Rate per 1,000 births.

Leigh .	.	.	.	.	.	.	.	. 37·3
Burnley	.	.	.	.	.	.	.	. 37·0
Radcliffe	.	.	.	.	.	.	.	. 36·0
Chadderton .	.	.	.	.	.	.	.	. 32·5
Wigan .	.	.	.	.	.	.	.	. 32·4

[1] Supplement to the 42nd Annual Report of the Local Government Board, 1912–13. Report of the Chief Medical Officer, p. 36.
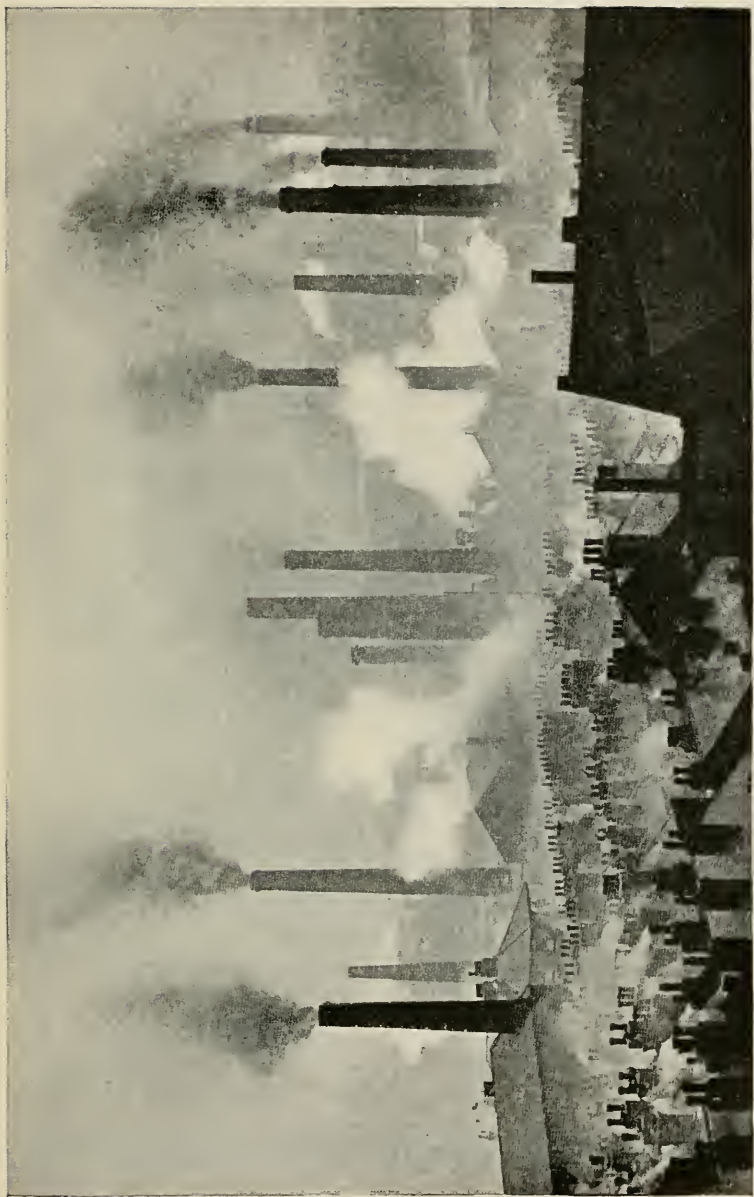
FIG. 21.—A photograph of the atmosphere in a part of Leeds.

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The lowest rates were found in :　　　　　Rate per 1,000
births.

Hornsey	.	.	.	.	.	.	.	10·8
Leyton.	.	.	.	.	.	.	.	10·7
Ilford .	.	.	.	.	.	.	.	10·5
Peterborough	.	.	.	.	.	.	.	9·5
Tunbridge Wells	.	.	.	.	.	.	.	8·7

In fact, the towns of the cotton district, where dirt and
moisture predominate, show the worst results, while the
districts where the free breezes blow from the sea across the
country-side, or where the towns have few strictly urban
characters, show the best results.

These figures should, however, not be pressed too far,
since there are so many factors concerned in infant mortality.
They provide, however, confirmatory evidence of a valuable
character to the argument already advanced as to the harm-
ful properties of dirt.　This is more especially the case when
present in a damp atmosphere, when the particles hold the
water and where the mild winds are rain-laden, but do not
sweep the air clean, as is the case on the west side of the
Pennines.　The keen, strong blasts on the East Coast are of
great benefit to health.

It is impossible here to dwell upon the effects of the
various dusts which are produced by different trades.
Those interested should consult larger works.[1]　It would
seem that all particles are not equally harmful, but that the
dangerous particles are those of silica dust (i.e. from stone),
which provokes no phagocytic action by the body.

The following tables show the varying effects on the death-
rate from pulmonary tuberculosis and the immense im-
portance of adequate ventilation :

DEATH-RATES FROM PULMONARY TUBERCULOSIS PER 1,000 LIVING IN
CERTAIN DUSTY OCCUPATIONS [2]

Occupation.						Death-rate.
Brick-maker	.	.	.	.	.	0·9
Coal-miner	.	.	.	.	.	1·0

[1] Oliver's *Dangerous Trades*, Oliver's *Occupations* (Camb. Univ. Press),
and a valuable summary of literature by Hill, M.R.C. Special Rept.,
Series 52, pp. 158 *et seq*.

[2] Compiled from lists of deaths published annually in the *United Opera-
tive Masons and Granite-cutters' Journal*, published in Aberdeen.

Occupation.						Death-rate.	
Mason (limestone)	.	.	.	.	.	1·4	
Iron-ore miner .	.	.	.	.	.	1·5	
Slate-worker .	.	.	.	.	.	1·8	
All males (England and Wales) 15 years of age and over	.	.	.	.	.	2·1	
Potter . .	.	.	.	.	.	3·1	
Lead-miner .	.	.	.	.	.	3·9	
Cutler (Sheffield)	.	.	.	.	.	5·9	
Granite-cutter (Aberdeen)	.	.	.	.	6·2	Uncombined silica dust.
Gold-miner (Transvaal)	.	not less than		13·8	
Metal-grinder (Sheffield)	.	.	.	.	15·2	
Mason (sandstone)	.	.	.	.	.	16·7	
Tin-miner . .	.	.	.	.	.	17·6	
Ganister worker.	.	.	.	.	.	22·3	
Flint-knapper .	.	.	.	.	.	41·0	

ABERDEEN GRANITE-CUTTERS [1]

Causes of deaths.	Class of employment.	Percentage of all deaths.	Median age at death.
Tuberculosis . .	Building section (open to the air)	25·0	54
	Monumental section (closed in)	38·0	45–47
Respiratory diseases other than tuberculosis . . .	Building section (open to the air) . . .	13·8	60
	Monumental section (closed in)	16·3	48–49
All other diseases . .	Building section (open to the air)	61·2	56–57
	Monumental section (closed in)	45·7	43–44

The second table shows not only that absence of ventilation causes a higher proportion of deaths, but also that the age of death is lower. The economic loss is therefore greater than appears merely from the death-rate.

It is hoped that enough will have been said to render evident the immense importance of getting rid of dust in houses. But further evidence is forthcoming as to the value of adequate cleaning and polishing. Schutze [2] took samples of the dust from all manner of places in a house and its furniture, and found that there was a great decrease in bacteria after a floor or a piece of furniture had been polished.

[1] Collis, *Milroy Lectures*, " Public Health," 1915, 28, 252 and 292.
[2] *Arch. für Hyg.*, vol. lxxvi. p. 297.

Everyone knows the clean, healthy feeling of a room that has been thoroughly cleaned and polished, but it is of great value to know that it is a fact as well as a feeling.

Sunlight also kills bacteria, and, taking the above facts into consideration, there is no difficulty in valuing the effects on health of a clean, airy, sunlit home as compared with dirty, stuffy rooms where either the situation does not admit of the entrance of sunlight, or its entrance is prevented by curtains and plants in the windows, or even by drawing down blinds lest the carpet should be faded. It is better that the carpets should fade than the occupants of the house.

CHAPTER VII

WE are told that cleanliness is next to godliness. Many hygienists and others whose paths of life have led them into a knowledge of the evils of dirty conditions, are sometimes tempted to think that without some measure of cleanliness, any high degree of godliness is well-nigh impossible. Those nations who have made progress in hygiene look upon self-respect as very closely connected with cleanliness. Unconsciously, from childhood upwards we have come to make a rapid general estimate of the social status and of the mental state of individuals by noting their appearance in the matter of personal cleanliness, under which heading that of order and disorder may well be included.

The close connection between disease and dirt which was preached by the early sanitarians is emphasized yet more strongly by their successors whose researches into the cause of many of the epidemic diseases lead us back with an almost impressive monotony to some form or other of neglect of the laws of order and cleanliness. For, in dealing with this matter, it is not possible to consider only personal cleanliness. This, while a most important branch of the subject, is only one of its many aspects, and will not alone suffice to reduce disease without adequate attention to the state of the surroundings of the individual.

GENERAL CLEANLINESS

Cleanliness must be taken as a whole, and must be regarded as referring to the state of the environment of the person. Of what service will it be to clean the house, if microbe-laden

dust is blown in continually from outside ; or to cleanse the
body, if the home itself is so dirty and vermin-ridden that the
clothing becomes reinfected immediately after cleansing ?
The process is merely disheartening, and even the stoutest
heart fails in time in face of overwhelming difficulties.

Cleanliness must be taken to include the cleansing of the
body, of the dwelling-place, and of the environment of that
dwelling. To secure this various agencies are needed. In
urban areas the Local Authority is responsible for the cleans-
ing of the streets, for the removal of refuse, for the condition
of the houses of the district, and usually provides special
cleansing stations for the person who is dirty as well as baths,
etc., for the continued practice of cleanliness. Vermin are
a concomitant of dirt, and the list of diseases which must be
laid at the door of these types of creation is continually
receiving additions. These, however, receive special atten-
tion in numerous text-books, and it will suffice here to men-
tion the more serious illnesses which are conveyed by this
means. The war has shown conclusively that typhus and
trench fever are carried from person to person by the body-
louse ; the outbreak of plague in India some years ago led to
the discovery that the rat's flea was the medium for the
conveyance of plague ; more recently the medical officer of
the London County Council has brought forward evidence
which he believes shows that the common flea may be held
to have a close connection with the conveyance of scarlet
fever.

Flying insects, again, carry disease, and, since their move-
ments are beyond control, the organisms which they can carry
and which can be deposited on food or on persons are infinite.
The only way to deal with them is to destroy the breeding-
places, namely, rubbish-heaps and decaying matter in the
case of flies, and stagnant water in the case of the mosquito,
different types of which carry the dreaded germs of malaria
and of yellow fever. Malaria has now died out in England
as the result of hygienic measures, but it is not many years
ago since this disease was by no means uncommon in the
fens of Lincolnshire and Cambridgeshire, and was known as

ague. The well-known mediæval legends of those parts, where saints struggled with devils in the swamps of that district, were almost certainly the ravings of the unfortunate victims of malaria. The drainage of the fens and consequent removal of stagnant water has caused the disappearance of the disease.

For the present purpose it will be convenient to divide the subject of cleanliness into two main divisions, namely, environmental cleanliness and personal cleanliness. Environmental measures will differ considerably in town and country. They are primarily concerned with the removal of the various waste matters whose presence arises out of the ordinary routine of daily life, and with the preservation of the dwelling itself in a reasonable state of order. In effect, the measures thus required are usually included under the general term—sanitation, which term, however, includes other points less directly concerned with cleanliness than the items mentioned above.

There are certain other matters which have important bearings on health and cleanliness, but which do not always receive sufficient attention from this point of view, such as the watering of streets and the flushing of street sewers.

The waste materials which require removing fall under two main headings—domestic waste and excremental waste. In a town the latter is usually dealt with by water-carriage, whereby the waste is led to some form or other of sewage works and there rendered innocuous. In some towns, however, only certain portions of the town are served in this way, the other parts having a conservancy system whereby the excrement is retained for a period on or near the premises (cp. Chapter III). Some of the systems are less unsatisfactory than others, which is all that can be said in their favour. Thoroughly bad hygienically, they require the greatest care both in use and in removal if cleanliness is to be ensured. This, unfortunately, is rarely the case, and these arrangements are frequently the source, not only of disagreeable odours, especially during the hot weather, but are also perennial sources of uncleanliness. They form ideal

breeding-places for flies unless they are emptied not less often than once a week.

Then there is domestic waste. This will include vegetable waste, together with offal from fish or other flesh food, tea-leaves, etc. Where an open fire is used for cooking most of this refuse could be burnt and thus disposed of hygienically in the home; but where gas is used, or an oil-stove, this is impossible, and the refuse must be collected and handled on a large scale. This is the duty of the Local Sanitary Authority, who should collect not less often than once a week and more often in the warm weather. Where there is much refuse a daily collection is desirable, and, failing that, there should be a collection twice or three times a week.

The refuse should be placed by the housewife in a bin reserved for the purpose, which should have a closely fitting lid. By these means the premises are kept clear of refuse which is dirty and malodorous (cp. fig. 6, p. 15).

Unfortunately, however, all towns do not undertake the adequate collection of refuse. In some districts there are large places where the refuse from a number of adjacent houses is thrown, and which, while nominally possessed of doors, are in effect open sheds, where the refuse mounts ever higher and overflows on to the surrounding area. This, being trodden upon by passers-by, and even played with by children, is carried on boots and shoes into the houses, rendering cleanliness difficult. Moreover, each gust of wind blows about the dust and particles from this obnoxious heap, making life hard for the cleanly housewife. Again, these places are breeding-grounds for myriads of flies, which enter the houses near by, alighting on the food and on all parts of the dwelling itself, leaving their marks of dirt behind them.

Waste or dirty water is usually carried off by the same water-carriage system which removes excreta. Where, however, this is absent adequate means for the removal of waste water are too often also absent. There is usually a street-gully, into which such water can be thrown; but it is

to be feared that not infrequently it is thrown down on the road itself, where it may run away, or evaporate, or remain according to the climatic or other conditions.

The proper disposal of refuse is an expensive matter, but the cost is abundantly repaid in the improved conditions of life and in the general health of the inhabitants. These matters are vital to the housewife, and it is greatly to be hoped that the municipal vote, now possessed by so many women, will produce improvements in this direction in those towns which at the present do not carry out their duties in this respect.

Then, in addition to the above, there is the general cleanliness of the roads. It should not be forgotten that, for all practical purposes, microbes may be regarded as present in all particles of dust. It is true that certain microbes are not directly harmful to human beings, but it is impossible to say which particles of dust may or may not contain the harmful varieties, and therefore all dust must be looked upon as harmful and every measure taken to reduce it. Roads should be kept watered in summer to lay the dust, and to prevent it from being blown into the houses. Observation upon the number of microbes in the air at the top of the clock tower of the Houses of Parliament showed that, as the day passed, the number of microbes increased owing to the stirring up of the dust by the traffic below (cp. Chapter VI).

Another all-important point connected with cleanliness is the question of the water-supply. It is not possible to keep a house clean unless there is sufficient water. But the water must also be of pure quality. Water for cleansing floors, etc., does not need to attain the same standard of purity as that which is required for drinking. But it must be remembered that two sources of water-supply may get confused, and it is well, if possible, to provide pure water for all purposes. There is a close connection between general health and a pure water-supply. This has been shown repeatedly by the improved figures for health which are found in towns when a good water-supply has been provided as against those which obtained with an impure one.

Personal cleanliness is evidently unattainable without water, and in fact rests largely upon the use of water in one direction or another.

Personal Cleanliness

Personal cleanliness constitutes a fundamental part of personal hygiene. There has, however, been a somewhat marked tendency to lay great stress upon it without remembering that it is only one aspect of this wide subject and not the whole matter. The care of the skin and the care of the teeth have seemed to loom unduly large in certain courses of instruction in hygiene. The care of the teeth will be dealt with under the hygiene of the alimentary canal, the outer person alone being considered here.

The need for cleansing the body arises from two main causes: the dirt which falls upon the body from without, and the secretion which reaches the skin from the tissues of the body itself. These differ in degree with different districts and with different persons. The dirt from without is increased in towns, or in very dusty areas, or from certain other special causes. Thus, in mining or factory districts, even in the country places, there is much outside dirt, as compared with the cleaner air of the rural areas where agricultural work predominates. In towns the dirt is further increased by the smoke from chimneys. Every one knows how easy it is to keep a house clean in the country, as compared with the continuous effort in the towns. Even with the exercise of much patience it is almost impossible to attain to that degree of cleanliness which is found in the country house of average cleanliness. The same amount of dirt which falls on the furniture or on the clothing falls also on the exposed parts of the body, such as the hands and face and hair. Further, the wind blows the dirt into the clothing, and some of it will find its way on to the part of the body which is covered with clothes.

Dirt is objectionable on account of its appearance on the parts which are exposed, quite apart from its detrimental

effect on health, so that these parts are more often attended to than those other parts of the body which are covered. Hygienically, the dust and dirt are bad because they tend to block the glands and to prevent the proper action of the skin.

Text-books on physiology all devote some space to the functions of the skin, but it seems doubtful whether the student forms any adequate idea of the importance of the skin in relation to the general health. Life cannot be carried on without the aid of the skin. If too large an area of skin is thrown out of work from any cause the body cannot perform its functions, and the person or animal concerned dies.

There are two kinds of glands in the skin, both of which must receive some attention in connection with the question of cleanliness. The sebaceous glands are situated in the walls of the hair-follicles and secrete a fatty material which is extruded on to the skin. This fatty material acts as a protective covering for the skin, and in cold weather probably aids in the retention of the body-warmth. Only the palms of the hand and the soles of the feet have no sebaceous glands, there being no hair-follicles on these parts of the body. The protection afforded by the fat secreted is known to those who have undertaken explorations into Arctic or Antarctic regions. These men have found it inadvisable to wash their feet for several days before exposing the feet to great cold. Frostbite is less likely if the foot retains its protective covering of the fatty material derived from the sebaceous glands. Fig. 22 shows the relation of these glands to the hair-follicles.

The sweat-glands are small coiled structures which are found in great numbers all over the body and are especially numerous on the palms of the hands and the soles of the feet.[1]

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[1] Metcalfe (*Essays and Notes on Hydro-therapeutics*, 1901) says that Erasmus Wilson counted the glands opening on to the skin with a magnifying-glass, and estimated that there would be some 7,000,000 glands, each about $\frac{1}{4}$ inch long, thus making about twenty-eight miles of glands in the skin of each person.

These figures are evidently only rough, but they give some idea of the immense number of sweat-glands and of their total surface for the secretion of water.

The fluid secreted by them consists principally of water, but
there are also small amounts of salts, urea, and other sub-
stances.   Some secretion of fluid is always going on from
these numerous glands, which passes off as water-vapour,
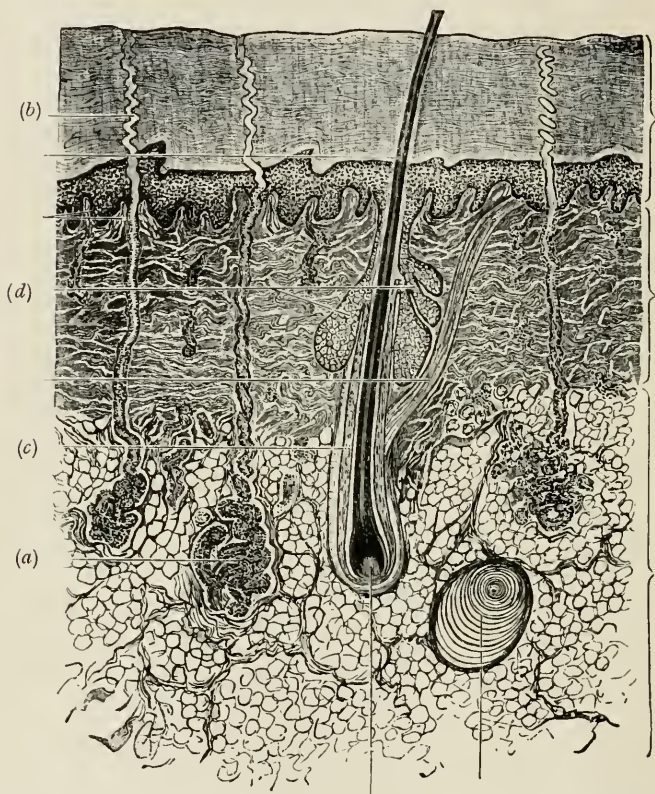and is often spoken of as the " insensible perspiration."

FIG. 22.—Diagram of skin.   Note (a) a sweat-gland and the duct of
another at (b) ; (c) the hair follicle, with (d) the sebaceous gland.   The
other structures are not referred to in the text.

Starling [1] gives the average amount of fluid which is thus
got rid of daily as 700 c.c., or about $1\frac{1}{4}$ pints a day.

    The amount secreted is, however, subject to wide varia-
tions, owing to the fact that the sweat-glands form a part of

[1] Starling's *Principles of Physiology*, p. 1302.

the system dealing with the body temperature. This is controlled by the central nervous system, which is connected with the sweat-glands by means of special nerves passing to them. If the temperature of the body rises the activity of the sweat-glands increases the secretion of water from the skin, and this, by becoming vaporized on the surface of the skin, abstracts heat from the body and helps to lower the rising temperature. There is, further, an intimate connection between the sweat-glands and the kidneys. Ordinarily the greater part of the fluid of the body which is passed out daily is got rid of through the kidneys. If, however, the weather be very hot the sweat-glands will be acting very freely in order to keep the body temperature down. They will secrete very considerable quantities of water and reduce the amount of urine secreted by the kidneys. Conversely, in cold weather the sweat-glands tend to secrete less water and the kidneys more.

In average conditions it is hardly probable that the amounts of salts, etc., secreted by the sweat-glands can be regarded as forming any important part of the total waste salts the body must get rid of. Where, however, there is much active work by the sweat-glands the amount of salts becomes far from inconsiderable. Most people find, after they have been taking a good deal of exercise, such as may occur in a long walk on a hot day, especially if there is a good deal of uphill work, or after dancing for a whole evening, that, if the body be allowed to cool gradually, a deposit of salts of quite appreciable amount can be rubbed off the exposed surfaces of the skin. The clothes will have absorbed the substances where the body is covered by them. Those parts of the body which are covered by clothing will therefore not show this to an appreciable extent, since the sweat will have been absorbed by the clothing to a greater or less extent according to the nature of the material worn.

In cases of disease of the kidneys the skin can render very powerful aid in the elimination of the waste material from the body. It is very important that the skin should be

kept in a healthy state and that the activity of the glands
of the skin should be freely maintained. If there were
no dirt from outside and if no clothing were worn it is
probable that the amount of washing which would be neces-
sary would be much less than is needed in the usual civilized
conditions of life. Under these conditions there is dust and
dirt from outside which varies in amount in the various
districts, and there is also the clothing which absorbs and
retains the excretions from the skin, and prevents the
removal of these substances by the action of the air, which
in the absence of clothing would play freely on the body.
Some of the substances are also retained by the greasy
nature of the secretion from the sebaceous glands. It is
therefore necessary that the skin should be periodically
cleansed so as to remove the waste matters which would
accumulate on it and tend to obstruct the orifices of the
glands.

Water alone does not suffice, owing to the greasy nature of
the secretion from the sebaceous glands, and soap is em-
ployed for this purpose. Also the dirt which the body
acquires from outside is usually slightly greasy, and will not
come away with water only. The requirements of cleanli-
ness are satisfied with ablutions which will remove the inside
and outside dirt, namely, with a basin of water and soap—
that is, of course, provided that the whole body be washed
and not merely the more readily accessible parts.

Owing, doubtless, partly to the inconvenience of washing
the whole body, the practice has arisen among most nations
aiming at progress in hygiene of immersing the whole body in
water or of providing some large receptacle in which the whole
body can be readily washed and cleansed. Thus, the prac-
tice of baths has arisen; but this practice, if extended, as
it nowadays frequently is, introduces other elements beyond
those of mere cleanliness, whose effects will be considered
more fully below.

A good wash all over once a day can be regarded as
sufficient for the ordinary individual in regard to the
body as a whole. The hands and face will, however, almost

certainly require more frequent cleansing, especially the hands. The hands are continually touching other things, which will be more or less dirty, and dirt contains germs. The dirty hand will, therefore, act as a disseminator of germs, and may even be the means whereby disease is conveyed to the food taken by the individual, or by others if that individual prepares the food.

It is not usual to wash the hair more frequently than once a fortnight, partly because the long hair commonly worn by women renders it a lengthy process, and partly because, if the hair is continually depleted of its greasy material, it tends to become unduly dry, leading to a loss of hair. It must, however, be remembered that the hair is exposed to dust and dirt in the same way as the rest of the body, except for that part of the hair which is covered by a hat when out-of-doors. The frequency with which the hair should be washed will differ with different people and according to the occupation and place of residence.

Especial attention should be devoted to those parts of the body which are less easy of access, such as behind the ears and between the toes, not forgetting the armpit and the parts round the anus and vulva. These last require scrupulous cleanliness during the monthly period, at which times increased care should be given. It may perhaps not be unnecessary to give a word of warning as to the cleanliness of the nails. These, if not kept short, provide a niche in which dirt can accumulate and germs be stored. Ordinary washing with soap and water does not cleanse the nails if these are allowed to grow any distance beyond that part where the nail is attached to the finger, or toe. If, for the sake of appearance, it is desired that the nail should grow, then much trouble must be given to secure cleanliness of the part between the nail and the finger. Anyone whose duties include the preparation of food should keep the nails short in order to avoid the risk of harbouring germs under the nails.

At the best a long nail can only be worn by those who have no manual labour of any kind to do, and the admiration of

a long nail may not unreasonably be looked upon as an acquired taste.

The cleanliness of the feet is most important. Much of the discomfort experienced by many persons, especially during the warm weather, is overcome by keeping the feet clean. A good wash with soap at least once a day will reduce the discomfort, and a wash twice a day will be better still. Those who have tender feet or whose feet perspire freely will do well to carry out careful washing twice a day all through the year, and at more frequent intervals during the hot weather (cp. Chapter X).

Baths.—The use of baths seems to be a feature of civilization. The uncivilized nations do not appear to have baths, and, as the general comfort of life increases, baths increase also. In this country the provision of baths in dwelling-houses of quite large size was not usual even some fifty years ago. Now, a bath is regarded as almost a necessity in any house, of whatever size. Practically all new houses which are built, even in rural areas, at the present time have a bath provided if the water-supply is at all adequate for its use.

Baths undoubtedly aid cleanliness owing to the greater ease with which a good wash can be obtained, but when used regularly and frequently they enter into another category than that of mere cleansing agents, especially if they are taken either very hot or quite cold.

Such baths tend to pass out of the purview of hygiene and to enter that of therapeutics. They produce definite effects on the circulation which may be beneficial ; but, if the baths are taken at too frequent intervals, the effects should be borne in mind lest damage result instead of benefit.

A bath in itself, without soap, is not necessarily the best method of cleansing the body. It is, however, very refreshing and stimulating.

A good deal of work has been carried out on the subject of baths, primarily from the standpoint of medicinal baths. Hot and cold baths have long been used for therapeutic purposes, and something is known of their effects, which are also applicable to baths taken in the course of daily life.

Fortescue Fox [1] says: " The moisture of a bath may be considered as a sedative influence combined with the stimulating influence of heat or cold. The general effect of the bath depends on the predominance of the one or the other influence. Moisture softens and relaxes the skin, separates the dead epithelial scales, and causes the deeper cells to swell by the imbibition of water." He explains that the amount of water absorbed is negligible for all practical purposes. Everyone will be familiar with the separation of the dead cells of the outer layers of epithelium of the feet after they have been a little time in water. Baruch,[2] in summarizing the literature on the effect of hot and cold water on the circulation, showed that the application of cold to any part produced an increased blood-flow to the parts adjacent.

A cold bath produces constriction of the arterioles of the skin and sends the blood to the internal parts. The effect of this is both to throw more work on the heart and to prevent that loss of heat by the skin which would occur if the arterioles did not become constricted. In fact, of course, some body heat is lost to the cold water, but more would be lost without this mechanism. The arterioles of the skin only remain constricted for a short period. Soon the opposing reflex commences, and the arterioles dilate. If the bath has been a short one the dilatation does not occur until the person is out of the bath, and the warm glow so much liked by those who are able to take cold baths is due to the dilatation of the vessels of the skin and the increased flow of warm blood to the periphery. Loss of heat then begins, which is, however, ordinarily prevented by the clothes. If, however, the bath itself be prolonged, then the dilatation occurs in the bath and the heat of the body is lost to the water, the temperature of which is raised thereby. The pulse-rate is slowed by a cold bath, the blood pressure goes up, and the heart-beat is fuller and deeper.

Roughly, it may be said that a bath at the temperature

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[1] *The Principles and Practice of Medical Hydrology*, chap. i.
[2] *The Principles and Practice of Hydrotherapy*, p. 35.

of the skin has no decisive effect, the temperature being one of " thermal indifference." This temperature is not absolute, and differs under different circumstances, and with different persons ; 93 degrees Fahrenheit may be taken as an average temperature for the skin. Fox [1] states that a cool bath leads to increased consumption of fat to supply the loss of heat. The loss rapidly increases as the temperature of the water used is reduced. At 86° F. the loss may be double that at ordinary body temperature, while at 68° F. the loss may be five times as great. Rubner [2] found that a brief cold bath caused a great increase in CO_2 output and a rise, but to a less degree, in oxygen intake.

Evidently, then, cold baths stimulate the circulation and throw more work on the heart. Those persons with normal hearts feel greatly refreshed by a daily cold bath in the morning, but there are people who do not feel that glow which should follow after a bath. That is to say, the reaction which should follow does not do so, and instead they feel cold and depressed because the heart has not responded to the stimulus. These persons should not take a cold bath, except perhaps in warm weather, when the temperature of the water may be such as will not produce a stimulus so intense that the heart cannot properly respond to it. A prolonged cold bath will always be depressing owing to the loss of heat and the increased combustion brought about.

A hot bath causes heat to be retained in the body. The warmth brings about a dilatation of the arterioles of the skin, but if, as is usual, the temperature of the water is above that of the body, heat will not be lost, but the heat which is always being formed by the body is not given off and the general body temperature is raised. The activity of the sweat glands is increased by the temperature. Metabolism rises in proportion to the heat and to the duration of the bath. A bath of 104° F. may cause a rise of body temperature of as much as five degrees in half an hour. The pulse-rate is accelerated, and the blood-pressure goes up with hot baths.

[1] Loc. cit.   [2] Quoted by Fox, loc. cit., p. 58.

Enough has been said to show that baths produce general effects on the body, and that they cannot be regarded merely as a method of cleansing. If taken rightly the stimulus is beneficial to normal persons. Cold baths taken when the skin is active, as, for example, after exercise, may throw too great a strain on the internal parts. Again, a cold bath at night when the body is fatigued is also undesirable for similar reasons. After a hot bath the skin is acting freely, and there is a tendency to loss of heat. Care should then be taken not to expose the skin to cold ; if taken in the morning the clothes should be put on at once, or if at night then it is wise to seek the warmth of the bed without undue delay.

Excessive and too frequent use of baths is enervating owing to the fatigue which arises as the result of much stimulation. Taken in moderation baths are beneficial as a whole, but some degree of discretion must be exercised. The monthly periods form no contra-indication to the use of baths, which may be taken freely at such times. It will usually be advisable to avoid either very hot or very cold baths, especially the latter, although some persons appear to experience no inconvenience from them.

The skin should be dried very carefully after a bath, especially in the folds of the skin. Moisture left on the body will evaporate, giving rise to loss of heat and subsequent possible chill. Young people not infrequently wish to take a bath immediately after exercise, when the arterioles are dilated and the skin-glands secreting freely. In such a case the bath should have a medium temperature. Cold would be dangerous for the reasons given above, and a hot bath would tend to raise the body temperature, already probably slightly above the average with the exercise. It is better not to rush for a bath immediately after exercise, but to wait a little until the effects of the exercise have somewhat subsided.

Sea-bathing lies somewhat outside the scope of this book. It is, however, perhaps useful to draw attention to the effects of bathing on the circulation. Müller [1] conducted an

[1] *Einfluss der Seebäder auf die Blutzirkulation des Menschen. Verhand intern. Kongress f. Thalassatherapie,* June 1911.

extensive investigation into the circulation after bathing
for 8–10 minutes in the North Sea. He found an increase
in the pulse-rate, together with a marked constriction of the
skin-vessels, which persisted for several minutes after coming
out of the water. The effect was accentuated on days when
there were waves of some size. He points out the strain
which is thrown on the heart, and emphasizes the need for
caution in bathing, especially if there be any doubt as to the
soundness of the heart and arteries. It is probable that the
effects are largely due to the cold water, and would be reduced
in warmer water than that of the North Sea. The added
effect of the waves, however, indicates that the temperature
is not the only factor.

Cleanliness does not, however, only mean cleanliness of
the body, but must be regarded as extending to the clothing.
The garments receive dirt from outside and collect the
secretion of the skin on the inside. This last soon gives
rise to an unpleasant odour if the garments are not washed
sufficiently often. All garments require washing or cleaning
at intervals which vary according to the nature of the
article and the stuff of which it is made. The edges of
garments where they rub against the skin are especially
very soon soiled, and require frequent washing.

It is difficult to bring forward any concrete statements
on the detrimental effects of dirty garments. Everyone
is well aware of the pleasant feeling of getting into clean
clothes after a journey, or when a clean set of clothes is
put on. It is not unlikely that dirt and its accompanying
germs exercise some subtle influence upon us without
producing any direct effect which can reasonably be called
pathological. We know that in epidemics death and
disease find their surest victims among those living in dirty
surroundings and who are themselves dirty both in their
persons and in their clothing. Possibly the continued con-
tact with dirt brings about a condition of low resistance
to infection, and dirty clothing may well be productive of
some form of the same process.

Brushing forms a useful adjunct to washing for certain

garments.   Hats, cloaks, and other outer garments, which from their nature cannot be washed very often, if at all, can be kept free from dust and from a good deal of dirt by frequent brushing.   In addition, the articles are themselves preserved and keep their appearance better than those which are not so treated.   Special care should be given to pleats or folds, and even to the seams of clothes, in all of which places dust will tend to lie unless brushed away. Again, it may be repeated that dirt and dust mean microbes, of which some will probably be directly harmful and against which precautions should be taken by effecting their removal, and if possible destruction, as rapidly as possible.

CHAPTER VIII

THE close relationship between good health and proper clothing has not yet been fully appreciated. This is due partly to ignorance and partly to the psychological aspect of clothes. It is probable that this latter factor has been of much greater influence than appears on the surface. Clothing may be regarded as having two primary objects : (1) to conceal the major part of the body for the sake of decency, and (2) to protect the body from the climate. The two objects are almost impossible to disentangle in surveying the ordinary garments worn in this country, and they are in a manner inevitably associated. Ordinarily the outer dress is worn for ornament, but may also serve to keep the body warm in winter, and the under garments act as protectors of the body against the weather. Both sets of garments should be modified to suit seasonable changes in climate. Clothing is further complicated by the need for cleanliness, which demands the use of washing materials or the need of cleaning by one or other of the various processes available.

The point of practical importance in the matter of clothing is to combine sufficient protection with adequate ventilation. The great value of this last is insisted upon in Chapter VI. Clothing which retains the body-heat too much, and which conversely prevents the entrance of air, may keep the skin in a state of activity over unduly long periods, and be the source of ultimate depression of health.

The skin is continually giving off water vapour, which, owing to the lower temperature of the air around the body, condenses into water, and subsequently undergoes evapora-

tion from the skin. In hot weather, or after much exercise, the sweat-glands are very active, and everyone is familiar with the secretion of fluid which occurs. This fluid gradually evaporates, but, in doing so, large amounts of heat are taken up from whatever substance there may be near it. If the fluid is lying on the skin, then the heat necessary for its vaporization is abstracted from the body. If the fluid is absorbed by a garment the place of vaporization is to some extent transferred from the body itself, being separated from it by the thin layer of air found between the skin and the garment. The presence of other garments outside the inner one acts in similar fashion. The object of putting on a warm garment after severe exercise is to reduce the rate of evaporation.

It is important that vaporization should not proceed too rapidly in warm weather : the vessels of the skin are filled with blood, and a rapid vaporization, by producing a rapid cooling, closes down the skin-vessels, throwing the blood into the inner parts of the body and giving rise to congestion and disturbance, which we term a " chill." The chilly sensation experienced is due to the rapid cooling of the skin, giving rise to a marked difference in temperature between the skin and the inner parts.

A good many investigations have been carried out on the relative merits of different materials as clothing. Much will depend upon the climate and upon the occupation of the individual. The materials most commonly used for clothing are wool, cotton, silk and linen, and the properties of these will be first of all considered, and then their consequent applicability as garments.

The power of absorption of water is clearly an important property of clothing. The amount of water which can be taken up by any material bears a close relationship to the amount of air it holds when dry. All materials consist of fibres ; these are smooth outside and hollow inside in the case of cotton and linen, while the wool fibre is solid in structure and its outside scaly. Woven or knitted wools hold large amounts of air in their meshes, as also does

cotton when loosely woven in several layers, as in the case of cellular cotton materials.

Water vapour penetrates into these materials with about equal ease, but the amounts of water the materials will hold vary considerably and are generally highest in the case of wool, although considerable differences are noted by various observers. Evidently the precise nature of the material used will cause wide differences in results, but, generally, the absorptive power of wool is higher than silk, and that of silk than that of cotton. Many materials retain considerable amounts of air in their pores even after wetting, as is shown by the following figures [1]:

1,000 parts.						Pore volume, dry.	Pore volume, wet.
Flannel	.	.	.	.	.	923	803
Cotton flannelette	.	.	.	.	888	723
Knitted silk	.	.	.	.	.	832	501
,, wool	.	.	.	.	.	833	612
,, cotton	.	.	.	.	.	747	517
,, linen	.	.	.	.	.	833	318
Smooth cotton	.	.	.	.	.	520	0

It is evident, therefore, that wool has both the greatest power of absorption of water and also retains most air on getting wet. Further, wool, owing to the structure of its fibre, does not lie so closely in contact with the skin, and will therefore admit of free ventilation, and will less readily take up heat from the body and bring about rapid vaporization of the water.

The degree of contact made by various materials was studied by Hill and his collaborators by taking disks of various materials, moistening them with a dye, and gently pressing them on paper. The impressions left are shown in fig. 23,[2] and demonstrate the great superiority of flannel over other materials. The degree of protection from cooling is also good with flannel, although the protection afforded

[1] Med. Res. Council Report, No. 52, p. 236.
[2] See fig. 36, M.R.S. Report 52, p. 236.

depends also upon other factors than the precise nature of
the material.

Taken as a whole, wool is clearly the best material for
wearing next the skin, and should be worn in varying
thickness of material according to the weather. Woven
garments which fit closely, but not sufficiently so to hamper
the movements of the body, are excellent, but well-made
garments of any kind of woollen material will also serve.
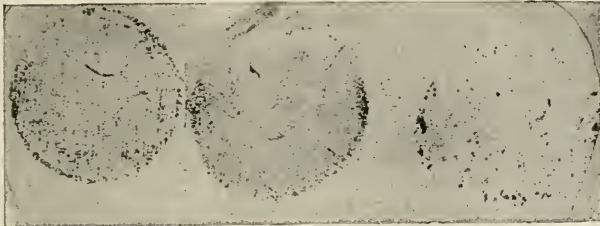
Flannelette.   Angola Cotton.   Flannel.
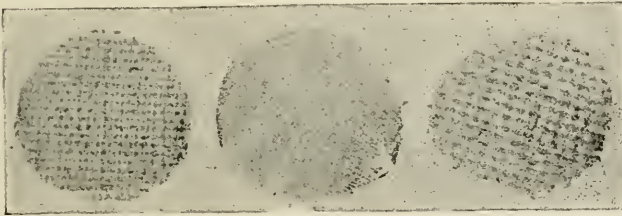
Cotton shirting.   Silk.   Cotton, open mesh.

Fig. 23.—Disks of the various materials, moistened with a dye (the
excess squeezed out). Laid on paper and a photographer's roller lightly
passed over them. The less the degree of contact, the less the impression
left.

(By permission of His Majesty's Stationery Office.)

Cotton in the form of calico, or one of the numerous similar
materials on the market, is not good, as is shown by the
figures already given. Plain cotton material is a good
absorber of moisture, and, while pleasantly cool in summer,
is not a safe article in regard to chills, owing to the rapid
evaporation from it. There are a number of special forms
of cotton garments which are a great improvement upon
ordinary cotton stuff. The cotton threads are woven so

that they form several layers, and hold much air, thus adding greatly to the power of the material to prevent the dispersal of the body heat in winter, and aiding the absorption of moisture in summer. Of these types probably Morton's and the Aertex cellular make are the best known.

Silk is a good absorbent, and if closely woven will act as a fair protection to the body in winter. It is, however, very expensive, and does not last very long. For the person of average income the two materials available are wool and cotton. Flannelette, which is made entirely of cotton, has a feeling which in some ways resembles wool. It is heavier in texture than ordinary cotton goods, which tends to produce a greater protection for the body. For this reason it is widely used as a substitute for wool among poor persons, but it does not replace wool from the hygienic point of view. Linen has advantages over cotton in retention of heat, but it does not absorb moisture readily. Flannelette, being cotton, is more inflammable than wool ; owing to its widespread use efforts have been made to render it non-inflammable. This is done by impregnating the material with mineral matter : on washing, nearly all this mineral matter is left behind in the water, and the flannelette is then again inflammable.

The value of layers of air for the protection of the body against cold should be borne in mind. Fur holds a large amount of air in between its hairs, and it is these immobile layers of air which make fur so warm to wear. Other things being equal, two garments of thin material will be warmer than one garment of the same material but of thickness equal to the joint thickness of the two layers. This is due to the non-conducting layer of air between the two garments.

The closer the mesh of the material, the more will it protect against wind. Rubber garments or other material of very fine mesh keep out the rain but give poor ventilation, and are therefore bad for the skin and general health. It is healthier to get wet out-of-doors and change the wet clothes on coming in. Although evaporation and loss of

heat are going on, the wet garments have been shown by
Hill to have almost as much protective power as dry ones
in preventing loss of body heat, especially if the material
is of a close mesh. So long as heat is being produced by
exercise there is no appreciable danger of a chill resulting
from wet garments. They should, however, be removed
at once on entering the house, when exercise ceases, and
dry ones substituted.

Dry, well-aired garments have been shown by Hill to
develop heat on becoming moistened. A thoroughly aired
garment affords the well-known feeling of warmth and
comfort, because, in absorbing the vapour from the skin,
it actually gives off heat (cp. p. 54 (footnote)).

The material worn next to the skin will also be in contact
with and absorb the other substances which form part of
the sweat and of the excretions of the body. The clothing
should not retain odours, and for this again wool is most
suitable. Cotton absorbs odours and requires even more
frequent washing than wool.

The garments which are worn between the inmost one
and the outer dress will vary a good deal both with the
age and fancy of the individual. In each case, however,
garments should admit full freedom of movement, and there
should be no constriction of any part. These will be dealt
with in further detail later. The outer garments for indoor
wear will vary with the season and to some extent with
the occupation. In this country, where central heating is
unusual in private houses, the garments require to be
warmer than in countries where central heating is general.
The garments worn out-of-doors will again differ with the
season.

It is important that the total weight of clothing should
not be such as to render exercise difficult, or to cause
fatigue to the wearer.

The outer garment worn in the house is usually the one
to which most attention is devoted in relation to its appear-
ance. It is this part of the clothing upon which people
depend for their general appearance, and it may be said

at once that society, with its communal life, demands that each individual shall show a certain standard of dress, which standard must include neatness and cleanliness.

The commoner articles of clothing will be discussed later in detail, and their unhygienic tendencies pointed out. Unsatisfactory as many of them are, they undoubtedly show a great advance upon those of even as little a while ago as twenty years, and, if the pictures of garments of earlier centuries are considered, the advance is found to be even greater.

Infants' Clothing

The principles laid down for clothing in general hold good for infants. They need one warm garment next to the skin, a further garment for warmth, and an outer frock. In the early period of life a napkin is necessary in addition. The warm garment should be of wool, and may profitably be knitted. A little vest, opening in front and having a free expansion to allow either for growth of the child or shrinkage of the wool, is best. It should not be so long as to become soiled, but it should be long enough to reach to the upper border of the napkin, to which it can, if necessary, be fixed with a safety-pin. Either the vest or the covering garment should have a sleeve reaching to the wrist (see right lower garment, fig. 24).

The binder of ancient days still holds sway in some districts, but is only mentioned here to be condemned. During the early days after birth until the remains of the umbilical cord have fallen off, there must be a bandage around the abdomen which holds the dry dressing of the cord in place. But when this latter has fallen off there is no further need for a binder. The old-fashioned binder was made of flannel and was some six inches broad, and long enough to pass several times round the child's body. The unfortunate infant was literally squeezed so as to secure the maximum tightness of the binder, which was then sewn up in such a way as, if possible, to tighten it still further. The child usually had the sense to resist stoutly, but its

efforts were of course unavailing against those of the superior adult force. Now this binder had many really harmful points. In the first place, it constricted the muscles of the abdomen and the organs inside the body. Muscles which are unable to be freely moved do not develop, but remain flabby, and there can be little doubt that much harm was done in this way by the binder. Further, the constriction of the organs is a pre-disposing factor to con-stipation, since the in-testinal movements are not free, and in addition the important aid of the abdominal muscles is lost, since these are hindered in their move-ment and development.

The binder, moreover, has a tendency to move upwards towards the chest, when it will leave its original site of the lower part of the ab-domen and pass to the upper part of the ab-domen and the lower part of the chest. Here it prevents the proper movements of breathing

FIG. 24.—Infant's garments, showing vest with long sleeves, opening in front, knitted binder, and garment for outdoor wear to cover the lower portions of the body.

—an all-important item—and may likewise interfere with digestion. The common plea given by mothers, that it helps to strengthen the child's back, is a fallacy, as it has just the opposite effect.

The binder is, however, dear to the heart of many, and some difficulty is often experienced in persuading the mother that it is unadvisable. As a temporary measure it may be necessary to use a knitted binder of sufficient size to slip loosely over the body (see lower left garment,

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fig. 24). But this, if carelessly and frequently washed, will shrink in time and become hard and tight to a degree that may be even worse than the old flannel one.

The chilly little cotton shirt formerly worn next the skin in infants has nothing to commend it, but is still found in certain districts.

The napkins can be made of Turkish towelling or other material, but whatever is used it is necessary that it should be material of good absorbent power and be able to be washed a great number of times. The outer flannel napkin formerly seen is hardly used nowadays, being hot and lacking in ventilation. Still worse was the mackintosh napkin which has even been seen in children's hospitals not so many years ago. The need for a large number of clean napkins must be faced, and also for continued washing. Napkins should never be used after merely drying, but should always be washed if once soiled. Where there are several children the napkins should always be boiled between use, as no child should wear a napkin which has been worn by another without previous boiling. Minor but subtle infections are conveyed by this means, although the origin of the trouble is not always realized.

The garment which is placed over the vest and napkin will vary a good deal according to the weather and to individual taste. Except in hot weather it is best of flannel and should stretch down over the toes to keep them warm. Sometimes a string is run along the hem and drawn up so as to keep the toes covered (see left-hand garment, fig. 25). This garment will need sleeves if the vest does not have them. The dress may be of any material, but it should not be very long (cp. right-hand garment, fig. 25). The long robe, while seemingly dear to the hearts of nurses and mothers, weighs down the tiny feet and prevents their free movement, and also interferes with ventilation. The dress is best made fairly plain, and it should not be tied up tightly round the neck nor be tight round the top of the arm or wrist. There are any number of pretty patterns suitable for dresses. Readers are referred for details

to some of the following books, which are only some of the many now published : *Simple Garments for Children,* and *Simple Garments for Infants,* M. B. Synge (Longmans). *Baby Clothing,* W. Hitching (Chambers).

The three-quarter length clothes for infants have the great advantage that they can be used until the child begins to crawl about, by which time they are probably considerably the worse for wear and a fresh set is needed in any case. The long garments which are replaced by

Fig. 25.—Infants' garments.   For description see text.

the so-called short ones at about six or eight weeks are unnecessary, and an extra expense. Many poor mothers, for this reason, will buy thin and unsatisfactory " long " clothes which the child has to wear during its most susceptible period immediately after birth, and is not kept warm in the more suitable clothes which are awaiting it a few weeks later. The importance of warm, loose clothing for infants can hardly be over-emphasized.

The outdoor garments should also be simple and warm but of light weight. The hood may suitably be a plain knitted one or a loose cotton one in summer. The air

should be allowed to reach the skin of the head. The thick padded and embroidered hood tightly tied under the chin is not hygienic, but is frequently seen. It appears to be considered very ornamental, and its use dies hard. The pelisse is often modelled on similar lines and of heavy weight. To the above is not infrequently added a thick woollen veil, so that the air, which the child is taken out to obtain, is effectually prevented from reaching it.

As teething begins the saliva dribbles out of the child's mouth. At this stage precautions should be taken to prevent the clothes getting wet. The saliva may soak right through to the skin, making the chest cold and risking an attack of bronchitis. Where the slobbering is very persistent a waterproof bib may be necessary, but a thick cotton one may be sufficient.

When the clothes are made short the feet need covering, and warm socks should be worn, but for the other garments the same principles apply as for long or three-quarter clothes. The flannelette skirt with calico bodice is most unsatisfactory. The bodice is stuffy without being warm, and the petticoat also gives little warmth. To remedy this latter defect several of these garments are frequently worn one over the other. This means more washing, and is certainly no cheaper than one good flannel petticoat with flannel bodice.

The loosely knitted overall gaiters drawn over the legs and feet and fastened round the waist are good for outdoors (cp. top garment, fig. 24).

The child who is never really warm will not have the same satisfactory circulation, and its vitality will be reduced compared with one that is kept warm. A really healthy, properly clothed infant will have a good circulation and its extremities and the body generally will be warm, which will materially aid its general progress. Again, the child who is overloaded with clothes may be too heated, but will be unable to secure the necessary movement of its limbs. In summer especially, it will tend to be fretful with the undue warmth of its clothing.

Elaborate embroidery and other forms of trimming have a tendency to make the clothing fussy or to be less warm than a plain garment. The child is better with simple garments which can be washed readily and without detriment to the articles themselves.

When the infant has reached the age when napkins are no longer essential little flannel drawers of simple pattern should be provided (see fig. 26). The not uncommon practice of allowing children to crawl about without any covering over the legs and lower part of the abdomen is thoroughly bad. It is bad both for the health and general moral standard of the child. It risks chills from sitting on the cold pavement or floor, and the lower part of the body which should be kept warm is not even covered, and will almost certainly be cold.

In addition the child gets into dirty habits, and if it has

Fig. 26.—Flannel drawers : simple pattern.

not already been got into good and cleanly habits it will not learn to be clean by having no nether garments on. On the contrary, the trouble will be made worse and will be more difficult to deal with at a later age.

Then, again, there is the risk of infection, which may be contracted by the child from the contact of the pavement or floor with the uncovered parts.

Older Children.—The age at which the sex of children is marked by a differentiation of clothing varies a good deal with the development of the child and the fancy of the individual parents. When, however, the differentiation has been decided upon the same principles as already given

above should be observed. The garments should be simple, warm, give freedom of movement to all parts, and be readily washable. Little boys will usually require a flannel shirt and drawers, or the trousers may be lined with some suitable washable material (see fig. 27). The cellular cotton stuffs are very good for this purpose. The trousers should also be of washable material, navy blue serge being very suitable for the winter. The majority of plain woollen stuffs will wash without detriment, however, if the washing is carefully done. Knitted jerseys are good for a further covering of the upper part of the body. These can be made out of various stuffs as well as being knitted. Thus the tops of ladies' stockings of which the feet are worn out, if cut open, make excellent little jerseys or frocks (see fig. 28). These are shown at many infant welfare centres, where other equally ingenious contrivances for economy can often be seen. Some kind of outdoor coat will also be needed for the winter. In the summer time the clothes can be made of lighter material, but it must be remembered that the child will run about and get hot, and that it will be better to retain a flannel shirt, so as to avoid the risk of chills.

FIG. 27.—Little boy's garments. Sweater and shirt above, trousers with removable washing lining below.

The garments for little girls should also be simple and plain. Plenty of room must be left for movement. Some form of

woollen vest or bodice should be worn next to the skin, and flannel drawers, at any rate during the winter. At the present time knickers have largely superseded the petticoat of former days even for little girls. It should be remembered, however, that these will require washing, and they should either be made of washable material, or should be provided with washable linings. The knickers themselves, even if lined, will also want washing at intervals (see fig. 29).

The other garments will vary very much in type according to the fancy and convenience of the mother. Chemises may be worn, or cotton combinations, between the vest and the knickers, or petticoats with bodices of different kinds. Above these an overall or a frock is usual, or, in older children, a blouse and skirt. Each variety of the upper garment has its points. The frock may give more warmth to the upper part than the blouse, as it will

FIG. 28.—Frock made from the tops of woollen stockings, whose feet were worn out. Sleeves can be added from the same material, if desired.

more often be made of warmer stuff. On the other hand, these are not infrequently made too tight, especially across the chest, thus constricting the proper movement of the ribs in breathing. Also the frock gets dirty round the neck and under the arms and probably does not get washed so readily as the blouse. A blouse, however, may be made of some light material such as cotton, and incorrectly be considered sufficient clothing even in winter. Woollen jerseys made similarly to those for boys are very nice for girls.

A few words seem desirable as to corsets for little girls. They are not at all necessary. The object of a corset is to support the breasts. Up to puberty the development of the breasts is so small as to be negligible. Corsets only hamper movement in girls, and, if tight or fitted with bones, will tend to constrict the figure and chest. There is, however, no harm in a simple unboned corset provided that it is not tight, and it can serve as a means of support either to suspenders for stockings or to petticoats if worn.

Fig. 29.—Showing white flannel blouse worn with loose serge dress ; serge knickers with removable lining, and flannel bodice on which the stocking suspenders may be fixed.

Suitable Footgear is of the utmost importance for both sexes. The feet should be warm and dry, not cold and damp. Socks are satisfactory for warm weather, but, if worn, they should not be supported on the leg by tight garters. Not infrequently children can be seen with red marks round the calves of their legs where the tight garter has pressed on the skin and underlying parts. Stockings which are carried over the calf of the leg will stay up better owing to the form of the leg, and a tight garter is not necessary. For little girls the stocking can be brought over the knee and held by suspenders from some form of small and unstiffened corset. The stockings should not, however, be so tightly strained over the knee as to cause any effort of movement in

walking. The stockings or socks should be of suitable warmth according to the weather. Thick stockings are needed both for boys and girls during the cold weather, though thinner ones may be worn during the summer. Stockings serve not only to keep the feet and legs warm and to provide protection against the hardness of the boot or shoe, but also to absorb the moisture from the foot when heated after exercise or in the hot weather.

There are two essentials for boots and shoes, namely, they must be water-tight and large enough. Damp feet owing to defective boots or shoes are a potent source of chills and illness. The feet are cold owing to the evaporation of the moisture, and cold feet are harmful to the general health. Some physicians regard damp, and hence cold feet, as predisposing factors of no less serious a disease than rheumatic fever, apart from less serious troubles. The importance of adequate boots for children is now widely appreciated, and many schools have boot-clubs for the scholars. Tight boots are bad. They give pain and make the child unwilling to take sufficient exercise. Further, it seems almost certain that the friction resulting from tight footgear produces corns and deformities of the feet which are detrimental to the individual throughout life.

Hats and caps are usually worn, but it is very doubtful how far they are really necessary except against great heat or wet weather. The wearing of a covering for the head is in this climate more attributable to custom or fashion than to its desirability as a protection. This is evident both from the experience of those who, in the country, seldom if ever wear hats, and also from the fact that, when it is fashionable to do so, numbers of women wear hats which are in effect either so small as to cease to be a covering, or composed of one layer of tulle, which cannot be regarded as forming any protection for the head. Yet no harm is found to result from these eccentricities of fashion. On the other hand, the air is allowed free access to the head and ventilation is secured for the hair and skin of the head. These are great advantages, and may have a favourable effect on the growth of the hair.

CHAPTER IX

CLOTHING FOR WOMEN

OF recent years the child welfare movement has attracted a good deal of attention to the clothing of infants and young children, so that it is now regarded as a definite part of child hygiene. Attention has, however, so far hardly been given to the problem of adult clothing in relation to general health. There can be no doubt that the importance of adequate and suitable clothing is fully as great for adults as for children, and that many ailments must be laid to the door of unsuitable garments.

With adult age the psychological factor comes into play, and fashion tends to be considered more than hygiene. The young woman rarely stops to inquire or even to think whether the fashions she follows are sensible or not, still less whether they are good for her health. The change of fashions brings alterations in the nature of the unsuitability of the garments worn, but most fashions have some aspects about them which cannot be regarded as other than unhygienic.

Speaking generally, it may be said that the clothing as a whole has become more reasonable than it was in former years, but this must be placed rather to the credit of the development of outdoor games than to the desire of the fashion-makers to produce suitable clothes for the health of the body. The discomfort which large numbers of women will endure for the sake of fashion is worthy of a better cause.

The same general principles should be observed as have already been set out for infants. Yet how often does fashion prescribe garments which constrict one part or another of the body, and which, by their nature and style,

cannot admit of adequate warmth in winter, in addition to many other evils or difficulties.

The undergarments should be sufficient for warmth and decency. As in infants, there should be a warm woollen article next the skin. Except possibly in really warm weather the lower part of the abdomen and the upper part of the legs should be covered by wool of varying degrees of thickness, according to the temperature and feelings of the wearer. The weather in this country is seldom hot enough to require specially thin woollen garments. The lower part of the abdomen should be kept warm. Many of the minor troubles of women are doubtless due to lack of this precaution, especially the matter of pain or discomfort at the monthly periods. A cholera belt, that is a woven belt, which can be worn round the lower abdomen and over the hips often answers the purpose very well, provided that the other garments are sufficiently warm. Over the warm vest or combination it is usual to wear some form of cotton garment —either a chemise or combination. These vary greatly in style and in material. In the case of those who wish to appear as slim as possible it is probable that the cotton garments are frequently omitted from the wardrobe. It seems impossible to suppose that the modest amount of clothing prescribed by the present fashions can secure anything approaching warmth during the winter.

The petticoat of days gone by has now been almost entirely replaced by knickers. In many ways this is a great improvement. The knickers are warmer if made with suitable material, and less bulky. They do not impede movement as do petticoats, and are much more comfortable. It must, however, be remembered that they require washing, and unless washed frequently should have linings which can be removed and washed every few days.

A petticoat of some material which will make the skirt slip easily is often worn over the knickers, or one of warm stuff to add to the general warmth. Again, however, it must be borne in mind that petticoats will need either washing or cleaning occasionally. Other articles of clothing

such as camisoles, etc., are purely a matter of taste; but a sufficient number of clothes should be worn in winter to ensure that the circulation is satisfactory in all parts of the body.

The little thin silk blouse so often seen even in winter cannot be regarded as an adequate covering, nor do the wearers usually pretend to a feeling of more than moderate comfort in the matter of warmth. Hygienically this is most unsatisfactory, and the very short sleeves of recent mode, together with the very low necks of dresses, have been even more unsuitable.

The shorter skirt is undoubtedly a gain both in the matter of freedom and of general cleanliness, provided that it is not carried so far as to be ugly, which is not infrequently the case. The long, trailing skirt of former days has, it is hoped, gone for ever. It was insanitary if not held up out of the mud, and fatiguing to the wearer when this was done. But dresses and coats and skirts all get dirty in towns and require periodic cleaning, especially the coats and dresses of the present fashion, which are worn against the neck, too often without any washable article between the material and the skin.

There seems to be a constant tendency on the part of fashion-makers to favour constriction of one part of the body or another. At one time it is the waist, at another the neck, and again at another the feet may be attacked for their size. All forms of constriction are bad, and to be studiously avoided. The form most prevalent with many fashions is constriction of the waist. Just now it is not in vogue, but will doubtless return unless women will have sufficient sense not to adopt it. Tight-lacing or constriction of the waist is not merely most uncomfortable, but produces troubles which cannot easily be put right later. Corsets may suitably form part of a woman's dress, but they should be worn loose, and be regarded merely as providing a support for the breasts and for the abdomen, where this latter is necessary. Constriction of the waist leads at once to difficulty in breathing. The breathing must inevitably

be of the purely thoracic type, since expansion of the abdomen is not possible. Interference with breathing leads to interference with free circulation, with its accompanying general disturbance.

In addition the tight waist will cause pressure on the abdominal organs, which, if continued, will probably produce indigestion, from interference with the functions of the organs concerned, and constipation from pressure on the abdomen, with possible displacement of some of the parts concerned. The troubles caused by this undesirable state of affairs are accentuated in pregnancy.

It is amazing that tight-lacing can ever be regarded as an attraction, since the body is not thereby diminished in size, but only displaced downwards, where the unnatural bulge produced is unsightly and unattractive. Ease of movement cannot accompany a tight waist, and this detracts yet further from the appearance of those who subject their bodies to the indignity of constriction of the waist.

Another site of constriction is the neck. The present fashion of open neck effectually prevents any constriction, and is good, but it is not long ago that high neckbands were worn or high starched collars. These, if they did not actually constrict the part, were usually sufficiently tight to restrict free movement and produced enough friction to be thoroughly uncomfortable when active work had to be undertaken. It is remarkable that these high, stiff collars are still adhered to by men, who usually make for comfort in clothes, and in the nurse's uniform, where an open neck and lace or muslin collar would surely be more comfortable and more suitable generally. Possibly the low collar might tend to be less tidy, but a stiff collar, when not properly fastened or when slightly soiled, can also have a very unsightly appearance.

An appreciable, but not extreme, constriction of the neck by clothes interferes with the return flow in the veins, leading to a sense of fullness in the head, and may even tend to produce headache.

Then there is the tight garter below the knee. There is

no need for it to be tight enough to cause constriction, although this is often the case. The garter is very usually now replaced by suspenders which hold up the stockings above the knee. Among the poorer classes, however, garters are very common. Suspenders, while good in principle, are sometimes so tightly fastened up as to restrict the movements of the knee and surrounding muscles.

The tight band below the knee is especially bad where there is a tendency to varicose veins, and may not improbably be a predisposing factor to this trouble. The constriction causes a decrease in the flow in the superficial veins which produces a deterioration in the vessel walls leading to back pressure and subsequent stretching, with the formation of varicosities and the attendant pain and discomfort of this condition. Varicose veins are far from uncommon among women of the working classes who have to stand a great deal, and are often in a poor state of general health.

The hygiene of the feet is very important. The remarks which have been made already on this subject in connection with children's clothing apply equally to adults, but there are other pitfalls for the young adult, which, if fallen into, lead to difficulty in later years. The care of the feet, however, is sufficiently important to require a chapter to itself. Inadequacy of protection for the foot is frequently found in the stockings worn. The best material for stockings is wool, and suitable degrees of thickness can be obtained to suit all weathers. The wool absorbs moisture from the feet in hot weather. The amount of secretion is not inconsiderable in most persons in hot weather or with exercise. Thread or silk stockings do not act in the same way, and are not warm enough for winter. The present fashion of wearing thin silk stockings with low shoes during the winter has no justification hygienically, and is not to be regarded as satisfactory. Stockings should be large enough for the feet, and should not be worn when shrunken in the wash, so that they compress the feet. More pressure is exercised by stockings than might ordinarily be supposed. The relief

experienced on removal of a stocking when the foot is slightly
swollen after exercise gives some idea of the continual slight
pressure which may be exercised throughout the day.   If the
stocking is too small in any direction, the compression will
be considerable.

Clothing during Pregnancy.—It is very important that
pregnancy should not be regarded as a pathological occur-
rence, but at the same time there are certain changes in the
figure inevitably connected with this state which call for
some modification in the clothing. The extent to which
such modification is made will depend in a wide measure upon
the taste of the individual, and to some extent on her
capacity to buy special clothes.

While there is no need to buy elaborate clothes of any
kind, there is equally no need for a woman to walk about
looking hopelessly unsightly, or even almost indecent, during
the later months of pregnancy. Some women, afraid of
being noticeable, hardly venture out-of-doors during these
last weeks, and this, again, is neither necessary nor good for
their health.   Either money, or care and forethought, is
clearly required, but with the latter a very small sum will
cover the required expenditure.

The undergarments will probably need little change,
but they should be adjusted so as to admit easily of breast-
feeding. The chemise, bodice, or blouse which does not
open in front and cannot be adjusted is incompatible with
breast-feeding, as the mother will certainly not undress
herself for each occasion. During pregnancy the breasts
enlarge, and the clothes should be widened so as to allow for
this development.

Corsets, if worn, must be worn loose, and must be large
enough to admit of the necessary expansion.   Special
maternity corsets can be purchased with elastic sides, but it
is essential that there should be no constriction of the waist
and no downward pressure on the enlarging abdomen.
Among multiparæ considerable pain and discomfort is often
experienced by the dragging of the abdomen. This is
frequently relieved by wearing an abdominal belt which will

support the abdomen round its lower parts. The belt is probably the best form of corset for pregnancy, and serves also to suspend the stockings. Garters are particularly liable to cause trouble during pregnancy, owing to the pressure on the large veins of the pelvis by the growing fœtus, which impedes the return of the blood from the legs. Any tendency to varicose veins is always accentuated at this time.

Knickers or a petticoat are still suitable, but they should preferably be suspended from a bodice, to which they can be fastened by clips or buttons, rather than worn supported round the waist. In this latter case they are very liable to cause some constriction owing to the trouble involved in the continued alteration in the size of the waist. A really loose piece of elastic may, however, serve the purpose. Such weight as must be worn should be laid on the shoulders rather than on the hips and abdomen. Maternity dresses need not be unsightly. Various patterns are found ; in some a blouse is worn under a loose apron bodice with a full skirt below, the bodice and skirt forming a one-piece garment.

The waist can be wide, and can admit of further extension, either by an elastic in the top of the folds, or by allowing for overlapping in the first instance, with subsequent alteration, either by tapes or some other form of fastening.

If the clothes are made plain, and in no special fashion, they can either be altered later into useful garments or can be kept for subsequent pregnancies.

The Psychological Aspect of Dress

Reference has already been made in the previous chapter to the psychological factor in regard to clothing. It would be almost as great an omission to overlook this side of the subject as to omit the subject itself from consideration.

Apart from the utility of dress in relation to the weather, it serves as an expression of personality in the most remarkable manner. It cannot for a moment be contended that the question of dress is one mainly of money. This, of

course, has a direct bearing on the kind of stuff of which the dresses may be composed or upon the number of garments which any one person may possess. Although on the surface it may seem to be a paradox, it is in reality the person who has not a long purse who usually shows her personality most markedly in her dress. The woman to whom money is no object will tend to follow the fashions slavishly, of whatever nature they may be. The more absurd and the more expensive, the more likely she will be to adopt them. She is led very largely by the dressmaker or by the shops she may happen to patronize. It is the business of both these to show the fashions, and they are only carrying on their work in dressing their clients in the latest vogue. There are, of course, a number of women to whom money is not much hindrance, and who take much thought as to the style, variety, and harmony of colour of their dress. They do not necessarily follow the fashion, but display their own taste freely in the clothes they wear. Their personality is displayed in their dress, and serves as a preliminary bond of union between them and their fellows of similar tastes, thus fulfilling the proverb which says that birds of the same feather will flock together.

It is, however, in those whose earnings or whose available means are small that the personality is most surely shown. The girl or woman who cannot afford more than a few simple blouses and a coat and skirt, or dress, must see to it that she selects suitable colours and materials that will look nice for as long as possible—that is, if she is wise. If, however, she selects materials that will not wash, and that soon get soiled and greasy, she must wear them in that state, unless and until she can afford to have them cleaned or to buy new ones. Or the cut may be peculiar, and not perhaps decorative, but only fashionable, and the stuff may fade or be of a material that will lose its shape. In the one case the wearer shows a capacity for facing the situation, and shows that she has learnt to adapt herself to her circumstances. In the other case the wearer has not been able to overcome her natural, and quite harmless, but unsuitable, desire for something

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that looks temporarily smarter, but that must be worn long after it has lost any suggestion of smartness. It may be contended that the first individual was not interested in her appearance, and did not really wish to wear the more fanciful or smart type of garment. In some cases, no doubt, the objection is valid, but in many persons it is evident that this is not the true explanation, as is shown in other portions of their attire where individuality also shows itself readily. In the days of neckbands hardly any part of the costume was more characteristic than the way in which this part of the dress was worn—whether it was tidy or untidy, in good or in bad taste, properly fastened or only partially holding together at the back, etc. But, in default of the neckband, there is the general way in which the garments are put on, and whether they are fastened carefully, whether there are fasteners not firmly sewn on, or whether the sleeves are of the right length, etc.

The hat, the way of doing the hair, the hands, and the gloves all again reveal unerringly the personality of the wearer. The hat may be of unsuitable size or shape or colour. It may always have been trim and neat or may once have been gaudy, but the trimming be now worn and dirty. The hair may be tidy or untidy, quietly ordered, or done in some eccentric fashion which shows the innate bad taste, or lack of taste, of the wearer.

The kid glove with a hole in it, or with a button off, denotes absence of care for detail, and compares unfavourably with the glove of humbler material which is neat and tidy. Boots or shoes all give indications of the personality of their owner.

With an inevitability which is almost alarming at first thought, the individual displays his or her character in his person, and the clothes form a not inconsiderable item in the general self-revelation. Posture and manner, together with facial expression, complete the picture, and it rests with the onlooker to read it aright. It is true that many people are unable to form any judgment that is approximately correct from outward appearance, because seemingly

they have not learned how to read the numerous signs of character shown by the individual.

There is a common belief among women that the opposite sex does not notice clothes. Never was there a more fallacious impression. It is probably true that the average man does not notice dress in the same way that the average woman may do. That is to say, he will probably afterwards be unable to tell whether the dress worn was of silk or satin, of tweed or of fine serge, but he will have noted the more essential matters, such as whether the clothes are generally suitable, whether they become the wearer, and whether the whole person had a neat or an untidy appearance.

Unconsciously in many cases important appointments are made largely on the personality shown by the individual in her dress and in the general appearance produced. Nor is this really an unfair method. The person who appears at an important interview without taking the trouble to be tidy will probably be careless in her work after appointment. Or one whose dress is dreary or dowdy will be unlikely to have an invigorating or stimulating personality. It is, of course, an effort for those with small means to look always tidy and be suitably dressed, and it can hardly be contended with any degree of justification that the effort is seriously reduced with habit. In those who are naturally tidy and careful no doubt the initial effort is less, but to many it proves a source of real and continuous effort. The daily mending of small matters, the incessant care for cleanliness, help no doubt to improve the self-control and habits of order, and thus contribute to the building up of character.

For the order of the clothing is an outward mark of self-respect or of its lack. The poor working-class woman becomes untidy in her dress in exact proportion to the retention or to the loss of her self-respect. She thinks that it is immaterial what her appearance may be, and this is bound up with her respect for herself. In the courses of instruction now arranged by the Scottish Board of Agricul-

ture the way to wear clothes forms one of the subjects of lecture.

Much more might be said on this subject, but enough has probably been said to show the main points. Physical health demands attention to clothing, and mental health suffers from a neglect of adequate care of the appearance. Undue self-respect leads to vanity, but the wise woman will try to take the medium course.

Notes on Clothing for Health Visitors

Health visitors will do well to remember that the working-class mother is sensitive on the matter of the clothing of her children. Any comments should be carefully made, and improvements secured gradually. One of the best opportunities is presented at the centre when the child is undressed for weighing. The clothing can then be seen without any difficulty, and the mother can at the same time be shown the model garments which should be a part of the equipment of every centre, however small. Another good occasion is before the birth of the infant, but at this period the health visitor must be careful that she does not interfere with the work of the midwife, who may have been already engaged.

The clothing of the elder children should not be forgotten. It can be seen at the school medical inspection, but these inspections do not take place at sufficiently frequent intervals to assist in the same way that the weighing at the child welfare centre will do. Moreover, the mother is not always present. A number of child welfare centres do not confine their efforts to the children under school age, but show models of garments for school children also. In this way a great deal can be done to improve the knowledge of the mothers as to the best kind of clothes for themselves and their elder children.

CHAPTER X

THE hygiene of the feet has not hitherto formed a part of the instruction given to the average medical student or health worker, and it is doubtful whether the great mass of the inhabitants in this country, at any rate, realize how much avoidable suffering they undergo on account of the lack of care of their feet.

The war has doubtless forcibly drawn attention to the unsatisfactory condition of the feet of many recruits, and also to the imperative necessity of a healthy foot for marching. A number of papers have been written on various matters connected with the feet of soldiers. One writer points out the deformities found in the feet of many Englishmen as compared with the feet of tribes who wear sandals and do not constrict the feet or walk on hard pavements.

While all this is helpful, it seems that the feet of the average man are still in a better condition than those of the average woman, and it is with women that this book is primarily concerned. It must, however, be remembered that it is before adult age is reached that much of the damage is already done ; attention to children's feet is of the utmost importance.

No one will dispute that there is a great number of persons who are hampered in their work and in their pleasures by their incapacity to walk or even to stand on their feet for any length of time. It does not appear to occur to them that much of this could be remedied by appropriate measures, and they have little or no idea as to what those measures should be. But prevention is at all times better than cure,

and adequate regard for the hygiene of the foot will obviate much discomfort and assist in the general enjoyment of life.

Few people probably stop to think of the work which is placed upon the feet. They do not realize that the whole weight of the body must be supported on the feet, which in addition are required to bear the stress and strain of footgear and the hardness of roads or pavements. The heavier the person, and the harder the road, the greater the strain on the feet, quite apart from the additional suffering caused by unsuitable coverings. Everyone knows among their acquaintance many who suffer from corns or tender feet, as well as from many other ailments connected with some trouble of the feet, which interferes with their enjoyment of life.

The great majority of these ailments are preventible even with the artificial conditions of life under which most civilized nations live. Some remarks upon the anatomy of the foot will, it is hoped, aid in the appreciation of the hygiene of this important organ.

The foot corresponds to the hand in its development in the human being, just as it does in four-footed creatures. During intra-uterine growth the hind limb of the fœtus becomes rotated so that the upper surface of the foot at birth corresponds with the back of the hand, and the under surface with the palm. Both hand and foot contain a number of bones of which those nearest the body form, with the long bones of the forearm and leg, the joint of the wrist and of the ankle.

Beyond this joint there are a number of smaller joints between the other bones, which number eight in the wrist and seven in the foot, which can be traced on the back of the hand or on the upper surface of the foot ; beyond these, again, come the little bones of the fingers and toes, being short in the foot as compared with the hand.

The bones are joined to one another by means of ligaments which stretch across the joint and help to hold the bones in place. Each joint is completely surrounded by

ligaments, within which are the white cartilage-covered surfaces of the joint areas. The ligaments are not tense enough to hold the bones in position by themselves, but depend also upon the other structures—muscles, tendons, fascia, etc., which lie on the outer surface of the joint. If these lose their tension and yield the ligaments cannot hold the joint surfaces in place.

On the upper surface of the foot, between the bones and the skin, there are mainly tendons with blood-vessels and nerves and connective tissue. There is very little muscular tissue, and in most persons the bones can both be seen and felt. No strain falls upon this surface of the foot.

The under aspect of the foot, however, has several layers of muscles, with their accompanying blood-vessels and nerves, together with important pieces of fascia and muscle tendons belonging to the muscles of the leg, which pass to be inserted into the bones of the foot. It is these soft structures which make walking possible. In some cases of disease where there has been a great wasting of the muscles of the foot the patient becomes almost unable to walk on account of the pain from the near contact of the bones with the skin against the floor or hard ground.

In the normal foot the whole of the under surface does not come into contact with the ground on walking. This is due to the fact that the bones on the inner side of the foot are disposed in the form of an arch. In infancy the whole of the foot touches the ground, but this is not due to any difference in the position of the bones, but to the presence of a pad of fat in the under surface of the foot. This pad of fat is gradually absorbed during childhood, and the inner side of the foot is thus elevated so that it does not touch the ground. The imprint of the normal foot on the ground is shown in fig. 30.

· This imprint suggests that the outer side of the foot has no arch, but this is not strictly accurate. The bones on the outer side of the foot have a slight arch, but very little as compared with that of the bones on the inner side. In addition to these longitudinal arches there is also the

transverse arch of the foot at the head of the metatarsal bones—that is, just before the toes are separated from one another. Tubby points out that the term "arch" in relation to the foot is erroneous, since the astragalus, the bone upon which the bones of the leg work, is not in the position of a keystone at all, but acts rather as a reinforced girder, with the piers placed obliquely. The astragalus is placed much nearer the heel than the toes, and the posterior limb of the arch is thus much shorter than the anterior one.

FIG. 30.—Imprint of a normal foot on a flat surface. The inner part of the foot does not touch the surface.

The outer arch does not usually cause much trouble, the inner arch being by far the more important. This arch is held up by the tendon of one of the leg muscles, the *tibialis posticus*, together with the strong fascia of the foot which passes from the heel to the toes, and the aid of the smaller muscles of the foot. Of these the tendon of the *tibialis posticus* is the most important. This muscle arises in the back of the leg, forming a tendon in the lower part which passes round the back of the ankle joint, turning to the inner side of the foot, and then dividing up into numerous parts which pass to nearly all the small bones of the foot. It thus acts as a powerful support to the various small joints. If this inner arch gives way a flat foot results.

The feet serve to support the body in standing and act as a lever to help the body forward in walking. Each time a step is taken the heel is first raised from the ground by the action of the muscles of the leg, and the weight is thrown forward to the ball of the foot. The reaction of the ground to the weight of the body throws the body forward on to the toes, and the bringing of the other foot

forward enables the foot to be lifted from the ground. The arch secures that elasticity of the foot which is so necessary for walking.

In the normal foot the great toe lies in a straight line with the inner side of the foot, or may even pass slightly towards the middle line of the body. Among civilized persons, however, in the great majority of cases the toe is forced outwards before many years of life have passed, giving rise to deformities which seriously prejudice the capacity of the feet to perform their work. Most of these are due to improper shape of the boot or the shoe.

Everyone must be aware that the shape of the customary boot or shoe does not attempt to correspond to that of the foot of the average person. Neither the narrow-pointed boot or shoe, nor the long boot with the square toe bears any resemblance to the true shape of the foot inside it. A fashionable shoe of the present day is shown in fig. 31.

FIG. 31.—A fashionable shoe, 1921.

The older literature seems to show that about the middle of the last century the fashion in footwear was very similar to that of the present day. Extreme heels were worn, and pointed toes. It may be assumed that they led to trouble, since there are various treatises of that period which deal with the normal foot and with the type of boots and shoes which should be worn to prevent foot trouble.

One of these writers points out that in their essential structure most human feet are alike, that the chief differences lie in the length and in the breadth of the foot, but that the other measurements are immaterial for all practical purposes if the shoemaker has a knowledge of the form of the foot. In the average shoe of the present day the foot is

Fig. 32.—X-ray photograph of a foot in a stocking.

FIG· 33.—X-ray photograph of the same foot as in previous figure, in a soft, pointed shoe. The toes are squeezed together and the bones displaced as compared with their position in fig. 32.

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elongated towards the toes, from pressure arising through lack of breadth. The toes are crushed into a shape which is quite unnatural. This is shown in the accompanying figs. 32 and 33 taken by X-rays, which show the position of the same foot with and without the shoe, which was of stuff, and soft. Corns are liable to form at all the points of pressure and friction, giving rise to pain and discomfort in walking. Actual deformities also arise requiring in many cases surgical interference for their correction.

The great toe is gradually pressed over the toe next to it, so that the joint of the great toe is pressed towards the middle line and is directly exposed to the pressure of the boot or shoe. The pressure and friction produce irritation and frequently lead to the development of the well-known bunion. This gives rise to a great deal of pain and discomfort, rendering walking a trial only to be undertaken when absolutely necessary, or necessitating the wearing of special boots, so made as to allow of ample space for the bunion. Further, the pressure of the great toe on the next toe leads to trouble. There is some difference of opinion as to the relative lengths of the great toe and the next one, but this is of minor importance for the question in hand.

The second toe, being pressed upon from above, tends to flatten at the extremity and to become hyper-extended— that is to say, the toe is contracted so that it projects on the back of the foot, and the tendon on the under surface shortens in adaptation. Other toes may share the same fate in bad cases.

This condition of the toes is known as '' hammer toe,'' and causes pain from the pressure of the boot on the prominent part of the toe, on which in addition a corn very frequently forms as a result of the pressure. Hammer toe is, however, by no means the only trouble produced by wearing improper boots or shoes. Nor does it always go so far as to produce severe pain, although some deflection outward of the great toe is extremely common. The crushing together of the foot gradually destroys the transverse arch, giving rise to pain which in some cases may be severe. Morton's disease,

where the pain is localized in the fourth metatarsal joint, may be caused by tight footwear. In this state the bones take up a false position which can often only be remedied by operation.

In most boots or shoes narrow toes are associated with high heels. These last are fully as harmful as the tight boot and their ill effects are not perhaps entirely to be distinguished from those caused by narrow toes.

Various ill effects arise from these high heels. In the first place, the centre of gravity of the body is thrown forward. The human organism is not as yet sufficiently adapted to the upright position to be able to stand upright without any tension on the muscles. In order to remain steady muscles must be in action to some extent. No one wishes to stand quite still for long. A change of posture is made unconsciously in order to relieve the muscles which are fatigued. By a change of the position of the centre of gravity an additional strain is thrown on the muscles concerned in order to maintain equilibrium.

Each time the foot is raised in walking it undergoes some degree of shortening. The heel is raised by the action of the leg muscles, which contract, and, in doing so, increase the arch of the foot slightly. Thus, the foot, when the heel is raised, is a little shorter than when it is on the ground. With a high heel the foot is continually contracted and the muscles have more work thrown upon them. They become, therefore, much more quickly fatigued, and the wearer of high heels is unwilling to take much exercise owing to the fatigue involved. Gradually the muscles become permanently fatigued and lose their tone, with the result that the inner arch of the foot is no longer maintained in its proper position, but sags, owing to the inability of the muscles already referred to to support the bones. This sagging allows of a slight displacement of the bones and gives rise to pain of varying degrees of intensity. The person has, in fact, become flat-footed with its accompanying loss of elasticity of movement and ready fatigue.

Tubby states that cases of flat-foot form two-fifths of all

orthopædic cases, and that among these females are found in the proportion of 67 to 42 in the case of men.

Flat-foot may also be caused by excessive standing, especially if the body is heavy or the tone of the muscles poor. Many people are obliged by their work to stand when they have already become fatigued, and when the strain on the leg muscles is therefore great.

Walking with the toes turned out throws more strain on the arch and tends to produce flat foot. Children should not be allowed to turn out their toes unduly. It is only a habit, which can be eradicated in the same way as other habits.

For children and girls who are growing rapidly boots are preferable to shoes. The upper part of the boot gives an appreciable degree of support to the ankle and to the foot. Hence, there is less tendency to tread over on one side or the other of the foot.

The low heel is intended to give slight support to the foot and to aid in raising the heel in walking, also to break the jar of the contact of the heel with the ground, which jar is transmitted to the body although it is reduced by the mobility of the joints. The exaggerated heel causes fatigue and renders its wearer comparatively incapable of movement.

The transverse arch of the foot is also injuriously affected by high heels. The weight of the body is now thrown forward towards the toes, and must be received by the ball of the foot. The transverse arch lies just above the ball of the foot, and it is this structure which in effect bears the strain on the ball. Hence it tends to give way and leads to the results already mentioned as resulting from tight boots. How unnatural high heels are can be seen readily at the present day. There are numbers of women who are clearly but poorly balanced on their heels, and must walk carefully to maintain their equilibrium. Admiration must be aroused by the amazing power of the human muscles to adapt themselves at all to the extraordinary position the body is made to adopt when high heels are worn. More especially is this so since in order, presumably, to reduce the weight

the heels are narrowed near the ground so that the individual
is required to walk upon a very small area of support.

These points were already noted in a book written in 1861
by a practical shoemaker who deals with the evil of improper
boots and shoes. He states that it was found by experiment
that, if the heel was brought far forward, standing was
impossible, as equilibrium could not be maintained. If it
was brought backwards it " caused insupportable pain in the
toes " (Dowie, *The Human Foot and its Covering*, 1861).
This shrewd observer makes comments which seem to apply
at the present day and are worth quoting. He says : " The
practical study of pedestrian exercise, with a view to the
physical well-being of the foot, is an interesting one to all
who have any regard for their general health. It involves
many important considerations for a thinking public : for,
when the foot is neglected in infancy and youth the after period
of life experiences a sad amount of suffering from persons
being unable to take the necessary amount of exercise that
their health requires. How many are there in this great metro-
polis who contrive, by every means in their power, to avoid
walking just because of their feet—their shoe pinching them
somewhere or other ? During the business part of the day
every short cut possible is taken to avoid that kind of exer-
cise which nature designed for the physical well-being of their
bodies ; and when they emerge from the bustle and smoke
of the city to the pure air of the suburbs, instead of enter-
taining the thought of a health-giving family walk, the pinch-
ing shoe is immediately pulled off, and the aching, imprisoned
feet flung upon the sofa in slippers in search of relief, while
the mind but too often finds consolation in attributing the
injuries experienced to everything else but the real cause."
Comment on this passage appears unnecessary.

Figures 34 and 35 show very well the position of the
foot with a high heel as opposed to the normal position.

The angle made by the bones of the foot with those of the
toes in fig. 34 should be compared with the corresponding
one in fig. 35. Also the position of the *os calcis* (the bone
which projects backwards, forming the heel) in the two

plates. The high heel throws the bone flatter, giving a less angle with the ground and causing the front lower part of the bone to press on the soft structures beneath.

Consideration must also be given to the general care of the foot apart from the question of the footwear. In warm weather or with exercise the feet get hot and moist. Ventilation is required to allow of the dispersal of the heat, and the moisture requires absorption prior to its gradual evaporation.

FIG. 34.—X-ray photograph of a normal foot, standing on a flat surface. The weight of the body is passed to the ground through the heel and the ball of the foot. The bone of the heel (*os calcis*) makes an angle with the ground and with the toes.

Shoes doubtless secure better ventilation of the foot, and stockings should be able to absorb the moisture. A thin woollen stocking is best for this purpose. A thread stocking does not absorb the moisture so readily and tends to become stiff and to rub the feet. Patent leather or rubber shoes prevent ventilation and are commonly said to " draw " the foot, making it feel hot and tender. Absence of ventilation and of the absorption of moisture causes the foot to become hot

and swollen. A cramping shoe or boot hampers the circulation in the foot, thus curtailing the proper supply of oxygen to the muscles of the part.

Where the feet have a great tendency to be moist some relief can be afforded by shaking a little boracic powder into

FIG. 35.—X-ray photograph of the same foot as in fig. 34, but in a high-heeled shoe. The *os calcis* is now nearly parallel with the ground, the long bones of the foot form a sharp angle with the toes and the weight of the body is differently distributed, as compared with the position in fig. 34. Less weight will be borne by the heel, and more by the joint and ligament of the foot.

the foot of the stocking each morning. If too much is put in it will tend to become hard on drying and will fret the foot. Those who suffer from tender feet should take care that they are kept scrupulously clean. The feet should be washed

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night and morning, soap being used on at least one of these occasions. Soaking the feet in water for 5 or 10 minutes, either with or without the addition of any chemical such as boracic acid or alum, gives considerable relief. The water may be warm or fairly hot. Cold water causes a reaction, making the feet feel hotter afterwards. Epithelial cells which have been cast off tend to accumulate between the toes and the bacteria which are present on the feet act upon them, producing a disagreeable odour. This odour can be obviated or removed by strict attention to cleanliness and careful washing in between the toes.

In some cases of discomfort, especially when the feet are fatigued after active exercise, much relief can be obtained by smearing them gently with a little grease such as vaseline. Stockings should be washed out every few days.

Corns are an overgrowth of epithelium, and cause pain by the pressure of the hardened mass on the soft tissues below. Many remedies are advertised, but it does not appear that there is any sovereign cure for them. Left alone, they may cause a high degree of debilitation. Many poor women are almost unable to walk from the pain caused by these large excrescences on various parts of their feet. The best remedy is to pare the corns as often as may be necessary with a sharp knife, being careful not to cause bleeding. This may lead to septic trouble, or at least to pain and tenderness at the spot for some days. This is especially the case in old people whose tissues may be in a state of low resistance. Or the epithelial overgrowth may be removed by snipping carefully round and under the corn with a pair of sharp-pointed scissors.

The whole operation is more easily performed if the feet have been previously soaked in hot water to soften the corns. Where the tenderness is great, as is sometimes the case in bad corns which have been neglected, a bread poultice overnight may secure sufficient softening of the corn to enable it to be dealt with less painfully. Those who fail to care for their feet will regret it sooner or later. Unfortunately, with children, the damage from too short boots or shoes is

often very much against their own wish, and due to the fact
that the boots have become too small but are " too good "
to be cast aside. It is most important that children should
be allowed boots giving room for the foot to grow. In
summer-time sandals have much to recommend them, but
in winter the cold is usually too great for them to be worn
without risk of a chill. Socks with a special place for the
great toe may assist in wearing sandals in cold weather.
These, however, are a good deal of trouble to knit as they
cannot be purchased in the majority of shops, but must be
specially made. Stockings which are too small in any
direction will also act prejudicially on the feet. The
constant pressure is greater than might perhaps be supposed.
It is almost certain that the stocking takes its share in the
pressing outward of the great toe, which has already been
dealt with earlier.

The value of exercise in the maintenance of health cannot
be disputed, but exercise requires the use of the feet. Those
who wish to retain their health should take care of their
feet. It is extraordinary how little attention many people
bestow upon these valuable and important parts of their
body.

No attempt has been made to discuss the form of shoe or
boot which should be worn. Special forms of sole or of
upper part are not within the means of the majority of
people. Moreover, if care be taken it is usually possible to
purchase boots or shoes which have low heels or which can
have the heels adjusted, and whose toes are broad enough
to avoid constriction of the foot. It is, of course, hard on
the individual woman to be obliged to pay for lowering the
heels, but it is the outcome of vanity of the rest of their sex,
and it is unlikely that the boot-makers will change the form
until there is more demand for a reasonable shoe than there
is at present. High heels and rather pointed toes are
usually smart in appearance, but if carried to extreme they
look silly and unsightly.

CHAPTER XI

IT is a fundamental law of biological science that nothing remains stationary, everything that lives must be either growing or must be passing towards decay. In man and animals the maintenance of life involves the use of the systems of the body. These systems are interdependent, and the work of one affects the others. The muscular system is the one we are most accustomed to consider in connection with use, and the term "exercise" commonly denotes the use of the muscles. Most people realize that there is a connection between muscular exercise and the proper performance of their functions by the internal organs. They know that children require exercise, because it helps to develop their muscles, and to make the body grow, and that exercise "does one good." The mechanism involved and the complex effects to which it gives rise, together with the results which may follow too little or too much use of the muscles, are somewhat outside the sphere of common knowledge. It cannot be said that our knowledge is at all satisfactory upon many of these points, but an attempt will be made in this chapter to set out as far as possible the elementary basis of the chief physiological processes and their application to the maintenance of health.

Although there are numerous gaps in our physiological knowledge, it is possible to build up a reasonably complete picture of the mechanism and effect of exercise on the various systems of the body. So soon, however, as we come to the application of these principles to daily life the borderline of the realm of psychology is reached, and the influence of the mind complicates the investigations. Up to the present this has tended rather to increase the difficulties.

Doubtless as investigations proceed it will be possible to
gauge more accurately the effects which are due to the
mind in contradistinction to the body.

All muscular movements made by an individual are
caused by impulses sent along the nerves to the muscles.
These impulses, which are of the nature of an electric
stimulus, produce a contraction of the muscle. No move-
ment in ordinary life is caused by a single muscle acting
alone. Each motion involves one or more groups of muscles,
each one of which must receive the stimulus through its
own nerve. It is beyond the scope of this work to consider
how far all impulses sent along the motor nerves to the
muscles arise as a result of sensory impressions, or how far
the higher faculties may be concerned. The points of weak-
ness in the system appears to be at the junction of the
nerve and the muscle substance and at the part where the
impulse passes from one to another of the neurones, those
numerous component parts of the central nervous system.
Muscular tissue will continue to respond to stimulation
after the point of junction of the nerve and muscle has
become incapable through fatigue of transmitting the
impulse.

Walking is a complicated process when first attempted,
but later, with continual practice, the adjustments involved
have become so familiar that the movements are performed
automatically and without mental effort.

Every time a muscle contracts it does work. Work
requires the expenditure of energy. The muscle cells
contain reserve stores of energy, chiefly in the form of gly-
cogen, but there are also other substances which may
perhaps be concerned in severe exercise. When the
muscle does work some of the glycogen is broken down into
simpler substances (metabolites) with the liberation of
heat and the formation of carbonic acid (CO_2) and water
(H_2O). In order to secure the complete breakdown of this
substance into carbon dioxide and water, a supply of oxygen
is necessary—that is to say, the blood must bring enough
oxygen to the muscles for this purpose. If the exercise

is prolonged the blood-flow does not after a time usually bring up a large enough supply, and as a result certain bodies are found, which are due to a partial breakdown of the glycogen instead of a complete oxidation. The most notable of these is lactic acid, which is ordinarily transformed into the simpler bodies CO_2 and H_2O, but requires oxygen for this purpose; other substances are also found, but in such small amount that they need not be considered here. The lactic acid is partly carried away by the blood-stream and exercises an effect on the body. It is not as yet definitely established whether the effect is primarily on the heart itself, which shares in the general deficiency of oxygen, or due to a specific action on the central nervous system, or to an insufficient oxygen supply to this latter.

The final result, however, is the onset of fatigue of the neuro-muscular apparatus, although this is by no means synonymous with the feeling of fatigue experienced by the individual during and after exercise. There is little, if any, direct connection between the fatigue of the muscle and the fatigue sensation in the person concerned. After the cessation of exercise the oxidation of the lactic acid proceeds gradually to completion.

The formation of lactic acid and the accumulation of other metabolites will eventually clog the muscle and prevent its effective working. It is probable that this largely accounts for the feeling of stiffness experienced after prolonged exercise by those whose muscles are not in training.

Many experiments have been carried out in order to ascertain whether the fat which is stored up in muscular tissue is utilized in exercise, and whether there is a destruction of the muscular tissue itself. It seems that neither of these occur to an appreciable extent so long, at any rate, as there is any store of carbohydrate in the body; but how far other substances can be used after the depletion of the store of carbohydrate, or owing to a shortage in this substance from special dietaries, has not been precisely determined.

Other processes are brought into play on the commence-

ment of exercise. Certain of the metabolites tend to produce a dilatation of the arteries in the muscles, thus aiding an increased flow of blood. At the same time the vessels of the splanchnic area are constricted, thus further increasing the amount of blood flowing to the other parts of the body. The dilatation of the vessels in the muscles is probably aided by the heat produced by the contraction of the muscles and subsequent liberation of energy. Then, again, the contraction of the muscles produces mechanical pressure on the veins, and forces the blood along them, back to the heart at an increased rate. A series of experiments has been carried out to ascertain the extent to which the blood-flow through the muscles is increased during their activity. Clearly the increase must depend upon the intensity of the effort, but roughly it would seem that the blood-flow may be increased from three to nine times the amount flowing at rest, the exact amount depending upon the condition of the muscles and the work required.

The increased venous flow causes the heart to fill more rapidly during diastole, which produces an increased pressure in the heart, and increases the amount of blood sent out by this organ. The heart, in fact, is called upon to do more work, a greater quantity of blood being pumped by it into the circulation. The rate of the heart-beat increases simultaneously, and the general blood-pressure rises.

The vessels of the skin also dilate, and the blood-flow through them is increased. This produces a heightened activity of the sweat-glands, and a loss of water from the blood. The metabolites in the muscles also retain fluid in the muscles themselves, so that the circulating blood tends to become less watery. A rise of body temperature occurs owing to the production of heat by the contraction of the muscles, some part of which, however, is got rid of by the evaporation of the secretion of the sweat-glands.

The effects of exercise are therefore far-reaching, and include a rise in blood-pressure, increased rate of flow of blood in the vessels, increased work of the heart, and in-creased pulse-rate, together with greater activity of the

sweat-glands, and greater production of heat. The cardiac and circulatory changes carry with them the necessity for an increased rate of circulation through the lungs, and for increased ventilation—that is, for increased intake of oxygen and elimination of carbonic acid. Respiration becomes deeper and more rapid with exercise, the extent of the change depending upon the severity of the exercise.

The deep and rather rapid breathing with which every-one is familiar after exertion is the response of the body to the increased need for oxygen. If the body is working efficiently and the exertion is not excessive, no distress is experienced. If, however, more work is laid upon the body than it is in a condition to bear without strain, breathing becomes laboured with the effort of the central nervous system to take in more oxygen and to get rid of the rising amount of carbon dioxide. It must not be forgotten that the heart itself is working harder, and that it shares both in the need for oxygen to carry on its work, and in the strain of working in the face of an insufficient supply. Co-ordination between the various systems concerned is required in muscular exercise. The more the individual takes exercise of any one or more types, the better does this co-ordination become, and the less strain does the work throw on the body. The body becomes trained to greater effort, and can accomplish many times the work with equal or even less effort.

The work done must not be increased too rapidly, but must be added to gradually each day. Violent demands made upon systems not in a state of efficiency are liable to lead to a breakdown in the machine, which may not be easy to remedy. Difficulty of this kind is frequently caused during holiday periods. Persons who have been taking little or no active exercise for weeks, or even months, find themselves in a country place or at the seaside with time on their hands. Impelled perhaps by a beautiful day, they take prolonged exercise, and return worn out. Nor does this fatigue pass off at once ; if the exertion has been very severe it may have effects which will seriously interfere with

the enjoyment of the remainder of the holiday. The danger is even greater where the change is being taken in a mountainous district. In this case the extra work of going uphill is added, and the body requires to adapt itself to high altitudes, where the oxygen tension of the atmosphere is reduced. Cardiac dilatation may result from the strain, which will be much more difficult to get rid of than it has been to produce.

Some degree of exercise is necessary for the maintenance of health. This is especially the case with children and young people. It aids in the development of the body, and should form a definite part of life. The feeling of movement is pleasurable, as is conclusively shown by the spontaneous movements of joy shown by children in their early years before custom and the exigencies of civilized life have curtailed the free expression of feeling. The healthy child commonly wants to be doing something. While it may be necessary to control the direction of the activity, and the child should be taught some measure of restraint, the desire for activity should not be curtailed. The child will cease its activity when fatigue supervenes. Some are lazy, and for these, efforts are required to procure the necessary amount of exercise for health. The active child should not be pressed to take undue exercise. The body is still growing, and requires time and opportunity for this process as well as for the repair of the daily wear and tear. The tissues are delicate and more susceptible to injury than those of older persons. Undue fatigue may prevent growth, especially if the strain is continued. The lack of development and the unsatisfactory health of the children who in days gone by were allowed to work in the factories supplied abundant evidence on this point, without entering into a discussion as to the conditions of housing and feeding under which they lived.

It is not always easy to determine where the border-line of safety lies. Roughly, however, a child should recover from its fatigue during the night's sleep. If too tired to sleep well, or if the fatigue persists on the following day, it

is almost certain that the exertion has been excessive. Or again, if exhaustion is noted on the cessation of the exertion, the exercise has probably been too severe. The child ordinarily stops short before exhaustion has begun, but there are some children whose energy, or desire to complete some given work or game, will carry them over the border-line. The child should be hungry after exercise; if it refuses to eat it is probably over-tired. Food should not be pressed in such a case, but the condition should not be allowed to recur. The body should be warm after exercise and the child should feel warm. If it complains of chilliness, or shows definite pallor, it will almost certainly have been over-exerting itself.

As the child grows older the capacity of the body for exercise should increase, and does so increase in the healthy child. There is no hard-and-fast rule that can be laid down. At the age of about seven or eight the child already has a desire to emulate the acts of its parents or its elder brothers or sisters. This desire may easily lead to the putting forth of effort which it is really beyond the capacity of the body to perform without undue exertion. Again, the amount of work which can be performed varies in different children. Some children are growing very rapidly and require more rest than others. Others show a muscular development which admits of greater effort than is usual in children of that age.

Their capacity for taking food and the nature of the food offered them will all make a difference in their capacity for muscular exertion. Those who are responsible for the health of children, whether their own or those of other people, will need to consider the children individually and not in classes according to their age, or to their intellectual progress. As adult age is reached the boy or girl is supposed to have enough experience of life to be able to decide to a great extent the degree of exercise that is good for him- or her-self. Sometimes the knowledge may be possessed, but does not happen to agree with inclination, and harm may be done, which cannot be remedied in after-life.

So long as the fatigue induced is repaired by a night's rest it is unlikely that serious damage is being done, even although the fatigue may have been well marked after the exertion. Young people have a great power of recuperation, and some degree of fatigue will not hurt them. If, however, the fatigue is frequently pressed to an extent that prevents recuperation during the night the danger-line may easily be overpassed and permanent damage be done to one or other organ of the body.

Walking is undoubtedly the form of exercise which produces the most general use of all the muscles without laying excessive strain on certain groups, unless the exercise is continually uphill or downhill. If this exercise can be taken freely without reference to mental work or to other duties, and if the person in question lives in a beautiful part of the country, walking will be a sheer delight, especially to those members of the community who are perhaps no longer in the flush of youth, and who take active interest in nature study. A walk taken purely for the sake of exercise along dreary roads whose every stone is known and where any interest is unlikely to occur is not felt to be a particularly desirable form of exercise by young people. Games are better, since they provide a stimulus to exercise and give mental enjoyment at the same time. The precise means whereby the mind affects the body are not known, but there can be no doubt at all that joyousness is good for the bodily health, while depressing mental conditions react unfavourably upon it. Whenever possible games should be played out-of-doors. It has already been shown that the body requires increase of oxygen when exercise is taken, and this increase is more easily provided in the open air than in a room, however good the ventilation may be.

Physical culture, which is now so widely practised in schools of all kinds throughout the country, is a good move, and valuable in developing the muscles and improving the circulation. It also trains the muscles to act in co-ordination and promotes intelligence in the pupils. It can hardly

be regarded as replacing the free exercise in the open air,
which should be obtained whenever possible.   The rambles
for nature study now often arranged for pupils provide
exercise for the body and interest for the mind, and are
greatly to be encouraged.

Games of all kinds are of great value, but may easily
be regarded as of more importance than is really the case,
from the point of view of mere physical development.   The
well-known games which are played by the youth of this
country, such as cricket, football, hockey, and tennis, have
the double advantage of providing a training for the senses
as well as for the muscles.   Properly carried out, they
should teach dexterity and co-ordination of the groups of
muscles.   Again, they develop a quick eye, a steady hand,
and should create that feeling of fair play and of team work
which are beyond the sphere of exercise and belong to that
of mental development.   Over-exertion in these is, however,
not uncommon both among boys and girls, and everyone
is by no means capable of the same amount of effort.
Rowing and running in university and other contests demand
so much effort from the heart that this organ may become
disordered and never completely recover.

Valuable as games are in the life of a nation, and much
as they have admittedly done to train the young men of
the country both physically and mentally, one is sometimes
tempted to wonder whether we may not have a somewhat
exaggerated idea of their value in relation to other matters
of daily life.

The quick eye, the sure aim, and the other acquirements
connected with games, all develop one specialized set of
actions of use primarily in those particular games, although
they may also have some value in other directions.   This
specialization takes place just at the time of life when the
mind is receptive and when fresh avenues of thought should
be opened out, and when the mind should be directed on
to broad lines of mental outlook, not of course neglecting
the physical side.

Those who, having reached the age at which they must

take up their life's work, have selected a line which involves sedentary work should take care that they make time and opportunity for some degree of physical exercise which will serve to maintain the organs in an efficient state.

During the life-time of the present generation the young women of the country have secured great advantages in the matter of games. These are most beneficial, but there are certain reservations which must be made. In the first place, the most strenuous games such as cricket and football, are not suitable for the average young woman. It is idle to pretend that the average woman is as strong physically as the average man, although there are certainly individual women who may be stronger physically than certain men. The onset of puberty is often a period when, without showing signs of actual disturbance, the tone of the body is not good. Many girls are anæmic, and the muscles flabby, with a good deal of superfluous fat. This is by no means necessarily due to the amount or nature of the food eaten, but may be attributable to the general state of the organism. Over-fatigue should be avoided in such girls until the body has reached a more stable condition, when the health frequently improves and more active exercise can be undertaken with impunity.

There is also the question of exercise at the monthly periods. So far as possible these should be regarded as physiological and not pathological. Unfortunately, however, the artificial conditions of civilized life tend to induce a good deal of minor disturbance at these times. It is difficult to make any definite statement as to the amount of exercise which may be safely taken. There are some people who experience no adverse feelings or effects during menstruation, and it may be that for these there is no need to curtail exercise even during the period itself. Others, again, and these form probably the more numerous class, while not indisposed, do not feel as well as at other times. In these cases, exercise, while it need not cease, should not exceed that which can be taken without incurring any special discomfort.

Very often the conditions improve greatly as the growth of the body ceases and the strain caused by the development of the sex functions passes off. It should be borne in mind that there is congestion of the pelvic organs during menstruation, and that while gentle exercise may relieve it by causing an increased flow of blood to the vessels of the skin, undue effort is likely to react unfavourably on the heart and circulatory system generally and to cause discomfort rather than relief. The fact that rest will often suffice to relieve the discomfort experienced seems to indicate that the body is in a state of strain which should not be increased by too active exercise. Undue strain repeated at each monthly period may give rise to unhealthy conditions of the uterus which may affect the whole life of the individual.

On the other hand, there is no need for a woman who suffers from a slight discomfort to imagine that she must necessarily remain indoors and perhaps fail to attend to her daily work. Unless this last should be heavier than is usually the case with women it will be much better for her to carry on as usual in spite of slight discomfort. Common sense and self-control must be brought to bear in deciding what amount of exercise may safely be undertaken by the young woman both during the periods and between them. A very strenuous life in between the periods may give rise to pain and distress at those times. Relief may be obtained by reducing the total amount of effort made on ordinary days. While there are no figures on the subject, there seems reason to believe that the very athletic woman of upright and tireless gait is by no means the most free from the minor ailments of sex or from difficulty in child-bearing.

Active occupation is good for women, and housework is not to be despised in this connection. While it should not be regarded as the only form of exercise necessary for the housewife, it provides a good deal of use for the muscles, which are kept fairly efficient. If the work were more regulated, as it easily could be, the exercise might be more beneficial. Too frequently, however, there is little organiza-

tion introduced, and the woman potters around for long periods, getting more bored than tired, and becoming overpowered by that sense of fatigue which, as already mentioned, has no definite relationship to pure muscular fatigue. If housework is done with open windows whenever possible so as to secure abundant fresh air and oxygen, and at stated times, and is briskly carried out, it is a great deal better than the idle life led by some women, or than the strenuous life of a factory or workshop.

It is unnecessary to enter further into the various forms of exercise which are prevalent in this country. Some are clearly more beneficial than others, but it is hoped that enough has been said to show the general principles which should be observed, and to demonstrate the importance of using common sense in relation to exercise.

It is necessary to consider more closely the phenomenon of fatigue, both in relation to muscular exercise and to brain work.

CHAPTER XII

MENTAL interest or excitement obscures the feeling of
fatigue. For example, a runner or athlete engaged in a
contest will perhaps quite early in the race experience a
feeling of physical fatigue. But he does not stop for this
reason. His desire to reach the goal before others, or to
assist his side in winning, carries him over this period.
Runners and rowing men experience what is known as second
wind; that is to say, after a comparatively short period of
muscular activity, the respiration, which had been ham-
pered by the excessive exertion, together with the heart,
takes on a fresh start at a higher level of activity. The
mechanism of this adjustment is complex, is not as yet
fully understood, and it need not be considered here. The
degree to which the organism will respond to excessive
exertion depends in great measure upon the condition of the
muscles and of the heart. In the final contest, where the
mental stimulus is strong, the man will continue to the end,
impelled thereto by psychological reasons. After the
contest is ended, the fatigue will be appreciated. This,
although possibly affecting his progress in the latter part of
the contest, has not prevented him from continuing the
exertion long after he would have stopped from fatigue
had there been no contest.

Great physical fatigue may prevent the mind from working,
and mental weariness may bring about a feeling of fatigue.
The first may be explained as being due to fatigue of the
heart and circulatory system, with consequent fall in blood-
pressure and decrease in the rate of blood-flow in the cerebral
arteries. In the latter case the feeling is probably not

physical at all, but is more likely to be due to lack of physical exercise. Prolonged brain work, involving a stationary condition, provides practically no muscular activity, and leaves the physical processes which produce heat at a low ebb. In most people a feeling of chilliness occurs after continued brain work, and is due largely to the absence of exercise of the muscles. Probably, also, the blood-pressure falls slightly, affecting the blood-flow through the brain. If considerable excitement is involved, the blood-pressure will be maintained, it being well known that cerebral excitement causes a rise of blood-pressure.

That feeling of weariness so well known to most people engaged in sedentary work is frequently relieved by physical exercise, and this should be the case if the work has not been too excessive for the individual concerned. Monotony in the work, or lack of interest, will produce a feeling of weariness at a much earlier stage than is the case if the work arouses interest. The amount of either mental or physical work which can be undertaken without causing fatigue differs in the individual, and also with the degree to which he is accustomed to the work. The rate at which work can be done, and the effort required to do it, are both greatly modified by practice Everyone knows how wearied one feels at the end of the first day at a new job, which, after a little experience, can be performed without any fatigue at all ; or the ease with which the same mental work can be done which as a child was found to be of great difficulty. In order to secure the increased facility it has been necessary to exercise the mind or the body, calling upon it each day to perform rather more than it did the day before. This can clearly only be carried up to a certain point, which will differ for different people, and will depend upon the nature of the work required. Due regard must be had to the special aptitudes or disabilities of the individual, but extraordinary results can be achieved by perseverance and proper training.

The following table shows the pulse-rate in two subjects doing approximately the same work, where one was a trained athlete and the other untrained. The effects are well

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marked, and show the relatively decreased effect of the exercise on the trained man, also the more rapid fall of the rate in the trained man.

HEALTHY MEN. PULSE-RATE BEFORE AND AFTER EXERCISE ($\frac{1}{4}$-MILE RUN). (PEMBREY AND COOK.) [1]

	Rest.	Just after exercise.	Counted during first minute.	Counted in first four successive periods of 15 seconds.			
				1.	2.	3.	4.
Trained .	76	150	135	40	35	31	29
Untrained	80	180	165	45	41	40	39

THE MEASUREMENT OF FATIGUE

Before it is possible to enter into a discussion on the question of fatigue, it is necessary to adopt some form of standard which can be used to demonstrate and, if possible, measure the degree of fatigue which is produced. This is in fact a most difficult matter, since many factors enter into the question, some of which are almost impossible to measure satisfactorily. Muscular fatigue is so bound up with mental weariness that it is impossible to obtain a clear picture of the effects of muscular fatigue alone. Again, it is not possible to measure the fatigue of the whole body; nor is it practically possible to measure only the fatigue of one muscle, since there is no one muscle in the body which works entirely independently of others. As it is known that the nervous system is the primary seat of fatigue, it is not difficult to see that nervous exhaustion will affect the amount of work the muscles are able to perform without fatigue.

The first method employed to estimate the condition of the muscles, and their capacity for work, was introduced by Mosso, who used an apparatus known as the ergograph. This is an apparatus for recording the amount of work done. Fig. 36 shows the method of working of the apparatus. The arm is held quiet in the apparatus, and the finger lifts

[1] Quoted by Bainbridge, Physiology of Musc. Exercise, p. 193.

the weight hanging over the table. In the original work
the weight used was roughly the maximum which the
experimenter could raise. Later experimenters showed that
after fatigue had supervened for that particular weight,
much work could still be done by the same group of muscles
if the weight were slightly reduced. In addition to the
portions shown in the figure, arrangements are made for the
extent to which the weight is lifted with each contraction
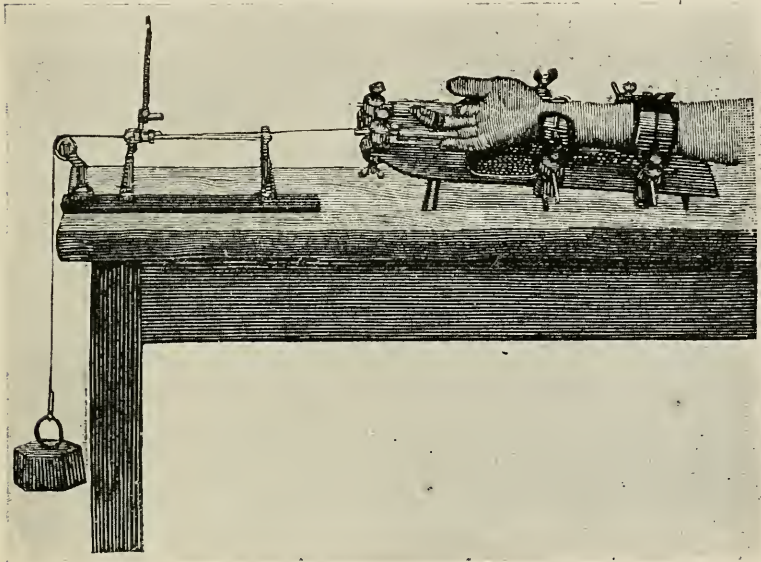
Fig. 36.—Mosso's ergograph.

of the finger, to be shown on a smoked surface, thus recording
the height to which the weight has been raised. Adjust-
ments are further made in the later apparatus by which
the total height of all contractions can be added together
as they are carried out. Other investigators have also used
a variable weight, or have made a group of muscles contract
against the force of a spring.

Rivers used a modified form of ergograph, and allowed two
minutes' rest between each set of contractions—that is, after

each period when the finger no longer lifted the weight. The record of the contractions is shown in fig. 37. An interval was allowed between each of the sets I, II, III for recovery. The figure shows very well the onset of fatigue on each occasion, and the subsequent recovery, which last, however, gradually becomes less complete in the successive sets. Rivers defines fatigue as " A condition of lowered capacity for work, which follows or occurs during the performance of work of which it is the direct result."

Mosso's method concentrates the attention of the subject on the muscular effort, and, as already mentioned, it shows the maximum amount of work that can be done with that particular weight. This aids in the elimination of outside factors, such as mental ones, because the factor of muscular fatigue is the prominent point in the mind of the person working. The amount of work done by the muscles increases with practice, up to a certain point. In daily occupation it remains stationary in the early part of the day, and then gradually falls off as fatigue comes on. Here, however, mental fatigue probably plays a not unimportant part. Various other methods have been used to measure mental fatigue, or fatigue of the special senses. In McDougall's apparatus the subject of the experiment is required to hit with a pencil, or other means of marking, a series of dots, which are made to pass in a slit in succession before his eyes. The rate at which the dots pass can be altered. They are marked on a strip of paper, and the experimenter hits them as they pass. Fresh pieces of paper are used for each experiment. Here the fatigue of the senses is being investigated. This method has been used to test the effect of drugs on the senses, also of tea, coffee, alcohol, and tobacco. The results obtained are considered under the appropriate chapters. (See under Beverages.)

Arithmetical calculations have also been used to test the degree of mental fatigue which is involved in certain types and amounts of work of this nature. Before such experiments can be undertaken with any chance of success, it is clearly necessary to establish some basis upon which the

comparisons can be made. The rate at which the individual can make the effort required must be obtained by experiment, since this differs with different persons, who, again, differ in the amount of work they can carry out, and in the time necessary for recuperation—that is, in the depth of fatigue induced.

A considerable number of such investigations have now
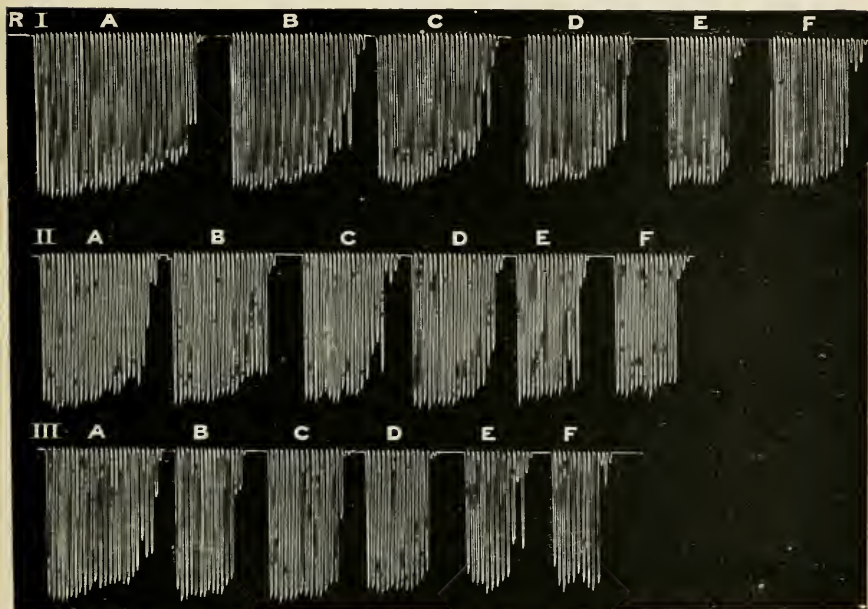
FIG. 37.—Note the dwindling height of the contractions as fatigue supervenes and the restored height after the two minutes' rest. Note also that after intervals the duration of work becomes reduced.

been made, more especially in the direction of work in factories, where, however, the muscular and mental fatigue cannot be separated.

An interesting investigation was carried out by Winch (*British Journal of Psychology*, 1911) on the relative condition of fatigue in school children in London, of different ages, in the morning and afternoon. Suitable mental tests were worked out, and the children were accustomed to

them. The results showed that in children between six and seven years of age, fatigue for reasoned work was so great in the afternoon as to render it practically waste of time. On the other hand, for the children, either boys or girls, in the higher standards there was no appreciable fatigue for reasoned work in the afternoon, especially in Standard VII. The mind develops with time, and the practice in work enables the older child to carry out the more arduous study without fatigue.

Any prolonged consideration of the question of industrial fatigue is beyond the scope of this book. Although our knowledge on this subject is at present only in its early stages, it would seem desirable to touch briefly on the main features which have emerged as a result of the many investigations made during the war in numerous factories. Some of them merely confirm facts already known, but are valuable as confirmatory evidence.

It has long been realized that the capacity for work falls off after a period of time, which will vary with the individual and with the nature of the occupation. Some interesting observations were made by Pieraccini, and given to the First International Congress on Industrial Diseases held at Milan in 1906. He investigated the amount of work which was done by type-setters during each hour of their working day, and also the number of errors made during each hour.

OUTPUT OF FOUR TYPESETTERS, SHOWING INCREASE OF ERRORS WITH INCREASE OF FATIGUE.

Hours.	8–9.	9–10.	10–11.	11–12.	12–2.	2–3.	3–4.	4–5.
No. of lines set :								
Total .	84	104	92	86	Rest	99	82	64
Average .	21	26	23	21·5	,,	24·7	20·5	16
Errors :								
Total .	17	10	18·28	28	,,	5·5	22·6	30
Average .	4·25	2·5	4·57	7	,,	1·37	5·45	7·5

Four type-setters were working together, and the total number of lines set, and of errors made, are shown, as well as the average for each worker obtained by dividing the total by 4.

Two primary facts emerge clearly. In the first place the output varies inversely with the presumed degree of fatigue, and in the second place the number of errors varies with the fatigue. The lag in the first hour of work has been found to be of usual occurrence, and is comparable to the getting into stride either in walking or in any other form of exercise with which everyone is familiar. Its explanation is more difficult. The highest results are obtained during the second hour, after which the output falls until the dinner hour. After the rest hereby obtained, the output rose markedly, to fall again more steeply towards evening. Although the rest had relieved the fatigue experienced before the dinner hours, it had not allowed of complete recuperation, so that fatigue of a deeper kind supervened comparatively soon after recommencing work. The combined and average output were less in the second hour after dinner than at any period during the morning. The same remarks apply in the main to the number of errors made at both periods of the day.

Very similar results are shown by the study of the number of accidents which occur at different times of the day. This was ascertained for the Departmental Commission on Accidents in this country in 1908. Similar investigations were also made in Germany and in the United States with almost identical results. The figures given below show accidents in the cotton industry in the years 1911, 1912, and 1913:

Hour of day.				Number of accidents.	Percentage of accidents.
Morning :					
7 to 7.59	.	.	.	695	6·49
8 to 8.59	.	.	.	970	9·05
9 to 9.59	.	.	.	1,275	11·90
10 to 10.59	.	.	.	1,485	13·86
11 to 11.59	.	.	.	1,438	13·43
Afternoon :					
1 to 1.59 .	.	.	.	885	8·27
2 to 2.59 .	.	.	.	1,253	11·70
3 to 3.59 .	.	.	.	1,382	12·90
4 to 4.59 .	.	.	.	1,327	12·39

Fig. 38 shows these results of the last column graphically.

It will be seen at once that the number of accidents show the same tendencies as the errors in the case of the type-setters in Florence. The number of accidents rises during the morning, to fall again after the midday rest, rising more quickly during the afternoon. It should be mentioned that
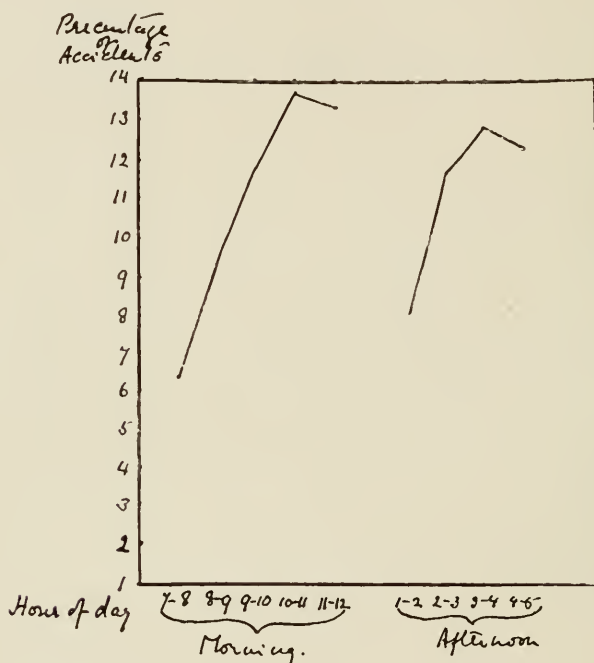
FIG. 38.—Showing the relation of the percentage of accidents to the time of day.

many operatives ceased work before the last hour in the afternoon, and also that all did not commence work at 7 a.m. The general tendencies are, however, clear, and are sufficiently precise for the present purpose.

During the war the output attained at works connected with material required for the prosecution of the fighting became an urgent national matter. Further, it was realized

that it would be necessary to maintain the health of the workers so that they could continue to work until peace should come. The difficulties were yet greater because the workers, especially towards the end of the war, were preponderatingly women, whose average physical strength must certainly be regarded as below that of men. The patriotism of the workers carried them through long periods of hard work, but the need for investigation into the health of the workers in relation to their work and also to the amount of work done, was realized, and wide investigations were carried out. It is not possible here to enter at any length into the results obtained, but certain prominent features require mention. Generally, it was found that long hours of work did not necessarily increase the output. The fatigue caused by the prolonged work rendered the rate of work slower, while a decrease in the working period of the day gave an increased output during the hours worked. As an example, the figures obtained from three winders are illuminating. During the first period of six working days (11 half-days) the hours were 6–8 a.m., 8.30–12.30 p.m., and 1.30–5.30 p.m. The average output during the two middle-day periods each day was 5,006 bobbins. The early morning period was subsequently dropped for six similar days, during which the average output rose to 5,630 bobbins. As might be expected, considerable variations were found among the individual workers. What is, however, most interesting, is that further inquiries were made as to the feeding arrangements of the workers and as to the food obtained. It was found that one of the reasons for the improvement arising from the dropping of the early morning shift was that the workers could have proper breakfasts before coming to work. Again, in other cases it was found that a good output was associated with the vicinity of home and that the worker was able to get good food at each meal.

Another interesting point was that of the time lost. It was found that this was greater with a long day than with a short day, and was evidently due, at any rate to some extent,

to real fatigue and not to laziness. For example, for three winders working

12 hours a day the time lost was					19·5	per cent.
10 ,, ,,	,,	,,	,,	,,	15·0	,, ,,
8 ,, ,,	,,	,,	,,	,,	13·3	,, ,,

Tests for the fatigue of the senses were carried out in great numbers, the state of fatigue or otherwise being gauged by the acuity of vision or hearing or of some other sensation. The results followed the lines already indicated. Where overtime is worked it appears that the night is not long enough for recovery to take place, and the worker may start the next day with an accumulation of fatigue from the day before or of earlier origin. Such effects will be more marked towards the end of the week. It is, however, curious that Monday tends to show great fatigue. This " Monday effect " is not fully understood, and is probably, in part at least, psychological. The conclusions reached by Professor Kent [1] are of great interest. In regard to overtime fatigue he says : " When once an individual has, through labour during ordinary hours, reached a certain degree of fatigue, and proceeds to further labour (overtime) without taking the repose necessary to dissipate the fatigue already produced, this further labour has a greater physiological effect, and exhausts the organism more than would a similar amount of labour performed when fatigue was absent. This is a well-known fact in physiology ; it is also a matter of ordinary experience. It is of importance in the present connection because it indicates that *overtime labour is more harmful to the worker than labour performed during ordinary hours*. It is therefore *physiologically extravagant*.

" The payment of higher wages renders overtime economically extravagant also. Yet higher wages are not sufficient to make it universally desired by the workers. Inquiries were made of 18 operatives in various departments of a large factory as to whether the overtime day with its extra rate of pay, or the ordinary day, ending at 5.30 p.m., would be pre-

[1] Second Interim Report on Industrial Fatigue, by Stanley Kent, published by H.M.S.O., Cd. 8335, 1911, p. 16 and foot-note.

ferred. In reply, 15 voted against overtime, the remaining 3 stating that they were indifferent in the matter." And again, " The general health of the worker, upon which his rate of working and his powers of endurance depend, so far as it can be gauged by the tests used in this investigation, appears to be prejudiced by the introduction of overtime, and, to a less extent, by work in the early morning hours. The suspension of overtime was followed in every case by an improvement in the condition of the worker. In a large proportion of cases that condition was further improved by the suspension of work in the early morning hours. Where an estimate was made of the time lost by the worker—and this was taken as an indication of his general health—the suspension of overtime was found to result in a saving of time of four and a half per cent. The subsequent suspension of the early morning period was followed by a further diminution in the time lost." [1]

The production of fatigue depends upon a number of factors, such as the habits of life, the relative strength of the worker in relation to the work done, the hours of work, the feeding arrangements, etc. Complicating the above are the psychological influences which, by affecting the mind, help to cause or prevent mental fatigue, according to their nature. Further investigations are being undertaken on these matters, and it is to be hoped that in the near future some of these difficult problems may receive elucidation.

It is well known that work which is congenial produces less mental fatigue than that which is disliked. Also, work which is familiar has the same effect. Often that which is fatiguing and even boring at the start, proves to have engrossing interest when familiarity and a commencing grip of the subject make it easy. While no one should allow themselves to be discouraged in endeavouring to carry out the work which falls to them, it cannot be disputed that equal facility is not possessed by each person for each kind of work. Probably everyone can reach a certain standard of proficiency in any subject, but facility is acquired unequally owing to

[1] Op. cit., p. 65.

the varying trends of mind of the different individuals. If no effort is made along unfamiliar lines, the mind is not called upon for effort, and does not develop, any more than the body will do if not used and made to work.

But reason must be exercised. The young child whose mind is capable only of mild effort should be taken gradually through its lessons, and not pressed with long hours or with hard routine or with cramping methods. It should, however, be encouraged to get over the difficulties with which it is bound to be faced, be the work ever so simple. Later, when the desire to excel enters into life, or even when troublesome examinations have to be taken, other phases occur. In such cases the mental stimulus may carry the exertion either of mind or of body over the physiological limits. This may arise not merely owing to the amount of work done, but to the time at which and the circumstances under which it is done. For instance, the amount of work done may not by itself be too great, but if in addition much time be taken for amusements, the combined effect may be disastrous, whereas a proper combination of work and play might have secured the desired result, and success have been achieved. Some relaxation is necessary, but it should be taken in moderate quantities and at appropriate times. Late nights in succession, coupled with perhaps still later hours of work, to be followed by a day of work and again by another night of amusement, will not long be endured by any organism. There are differences in the strain that can be borne by different people ; some will succumb very quickly, while others hold out for some while. Also, youth has powers of recuperation not possessed in later years, and the young man or woman will often show surprising powers of endurance both for amusements and for work. During young adult life the powers are perhaps sufficient to warrant some degree of risk, provided always that too great risks are not taken. If the limiting line be overstepped, and complete recuperation no longer takes place in the time allotted for rest, a breakdown may occur, which often takes years to recover from and may even show its effects all through life. It

would seem almost as if the very power of recuperation possessed can be a danger, leading the person concerned to believe that it is inexhaustible until the terrible time comes when it is exhausted.

In later life recuperation is slower and over-fatigue less easily recovered from. The staying power is, however, usually greater owing, probably, to a reduced mental excitement, which last may in itself produce considerable fatigue, and which is more frequently present in youth.

It should also be remembered that proper food and attention to the needs of the body generally make an immense difference in the amount of work that can be carried through without strain. Young women and girls especially are apt to regard such matters as too mundane to receive adequate thought, and they refuse to believe that these points are of fundamental importance if the work that falls to them is to be satisfactorily performed.

CHAPTER XIII

REST AND SLEEP

BOTH rest and sleep are necessary for the maintenance of
life. The various systems of the body cannot carry on
their work continuously : there must be intervals when no
work is demanded of them, so that they may recoup them-
selves and recover from the wear and tear of the previous
period of work. The circulatory and respiratory systems,
which must be continuously meeting the needs of the other
organs, have brief intervals of rest after each brief period
of work. Inasmuch, however, as these brief periods recur
many times in the course of a minute, the total amount of
rest obtained by these systems in the course of the twenty-
four hours is very large. In the heart, if the average time
of the complete cycle be taken as ·8 second, then the heart
is at rest for just over one-half of the period : the total
periods of rest in the twenty-four hours would therefore be
more than twelve hours. This is only an average statement,
as the actual amount of cardiac rest in each individual will
vary with the rate of the heart-beat, which is influenced by
many other factors.

Other systems are required to work practically con-
tinuously for prolonged periods, during which there is no
opportunity for rest and therefore for recuperation, so that
it is necessary to arrange for definite periods of reasonable
length during which the various organs can repair their
waste and re-create tissue to replace that which has become
worn or damaged. It is hardly correct to regard the body
in the light of a mere machine, owing to its great complexity
and to the undoubted influence of the mind. It is possible
that, with added knowledge of its working, many things will

be found to be less complex than they at present appear. It is, however, clearly established that if health is to be preserved, the several systems of the body must be in a state of efficiency. They will only be efficient if they are in a proper state of repair, and they cannot be in repair unless time for recuperation is allowed. We are not able, nor is it necessary, to state precisely how much rest should be taken after any given period of exertion. The varied and subtle influences which are always at work, or which can be brought into action if needed, provide for fairly wide limits, both of exertion and of rest, within which the efficiency of the body can be maintained.

Again, these limits vary with the individual, and depend upon hereditary influences and environment, and also upon general habits of life. One of the real difficulties in connection with the hygiene of the individual arises from this very complexity and absence of well-defined limits. Sufficient knowledge, some thought, and often a good deal of self-control are required in order to maintain the right proportion between rest and work.

If too much rest is taken, the systems of the body gradually lose their efficiency and begin to deteriorate, or if insufficient work be undertaken during the period of development, the degree of development reached will be below that which was possible. It is probable that the degree to which physical development is lacking from insufficient physical work or exercise is very much less than that on the mental side. The ordinary animal spirits of the child and young person will, unless there are special hindrances, lead to at least enough bodily work or exercise to ensure development up to a reasonable point. There can, however, be little doubt that such a point is considerably below that which might have been attained had special methods been employed and special attention devoted to physical development. On the other hand, it can hardly be doubted that the limit of mental development reached by the average individual in any country is much lower than could have been reached with a very small additional amount of mental effort.

Presumably, the faculties being of a later stage in evolution than the body, greater effort is required to induce them to work actively. The lop-sided or undeveloped mind is less visible outwardly than a defect of the body. It is, however, a mistake to suppose that it is not fairly readily discernible to the psychologist who knows how to look for it.

As a nation, English people dislike being made to think for themselves : we prefer to be told by those who may be supposed to know, and a clever catch-phrase is often widely accepted as a correct statement because it sounds plausible. A little thought would often show its fallacy. Many children have inquiring minds, and ask intelligent questions, which those in charge of them are frequently unable to answer, but on which they are not prepared to admit ignorance. Thus the child's mental development is retarded and often stunted. The mere acquisition of knowledge should not, however, be regarded as the only form, or even the best form, of mental development. The capacity for reasoning and for balancing advantages and disadvantages is a branch of mental work which should be encouraged, and which often requires more real mental effort than any form of learning.

The tendency to insufficient mental effort is probably more widespread among women than among men. It is less trouble to let matters involving real thought be settled by their brothers or husbands ; and the majority of men do not seem to be anxious to put an end to the mental apathy of their womenkind. Yet such apathy is unhygienic, both for mind and body. The girl or woman whose mind continually traverses the easy and well-known details of everyday life, without any effort at improvement, becomes mentally lethargic and unable to carry the mind either to a higher standard of her daily life or duties, or to outside matters of wider import. So long as life goes smoothly the waning of her faculties is not perhaps realized. But for everyone trouble and difficulty will inevitably come sooner or later, when mental efforts must be made if life is not to be dreary and purposeless. The bodily health is very

dependent upon the mental outlook. If the mind have no interest it will react unfavourably upon the body. In the absence of mental occupation, physical ailments, either real or imaginary, assume an altogether undue prominence, which only too frequently leads to one of the various forms of nervous disorder with accompanying physical incapacity.

Too much repose of either mind or body is to be avoided just as much as too little rest.

A good deal has already been said in Chapter XII as to the ill effects of continued fatigue and over-exertion, and it is hardly necessary here to do more than deal with certain practical points relating to rest. It is very commonly stated that the twenty-four hours of the day and night should be divided into three equal periods—eight hours' work, eight hours' rest and recreation, and eight hours' sleep. While this should be widely modified in practice, in accordance with the age of the individual, it may be regarded as a fair statement for the average adult man or woman. The period of sleep should be continuous, but not the periods of work and rest : these require some adjustment. There must be intervals of rest for the taking of food, and there are intervals which will fall within the period allotted to rest, which will be absorbed in the other daily functions of life such as rising and going to bed, washing, etc. A portion of the eight hours' rest should be allotted to some form of recreation—that is, to some diversion, either mental or physical, which will carry the individual away from that on which he is engaged during the eight hours of work. For those whose daily work consists primarily in physical effort, the recreation may profitably be that of reading some interesting book, or some other form of mental diversion. Those whose occupation is mainly sedentary, or who work indoors, should devote a part of their period of recreation to outdoor exercise. It is apparently often believed that, if an occupation involves much standing and consequent fatigue, no exercise is necessary. Standing is fatiguing, but it does not replace the need for exercise, and much of the feeling of muscular weariness will disappear with a short,

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brisk walk in the open air. The circulation will be quickened, and the feeling of fatigue, which is often also partly mental, will fall away.

It is frequently asserted that the average housewife has no time available for recreation. Doubtless there are certain cases when it may be difficult for her to secure this, but in the great majority of cases it is due either to lack of method in arranging her work, or to lack of knowledge as to how to do it. A contributing factor lies in the fact that, except as to certain matters, there is no absolutely fixed time within which certain pieces of work have to be finished. The wise housewife will have at least a general outline of her work planned in her mind for the time of the day and for the days of the week, and, without necessarily adhering to it rigorously, she will see to it that the work is done in general accordance with her plans. By so doing she will be able to arrange for certain periods of rest and recreation each day. Rest should be arranged after meals, especially after a substantial meal, in order to allow the necessary blood-flow to the stomach. If exercise is taken the blood is diverted to the muscles and skin, and digestion is hindered.

Rest after any special exertion, or at the end of the day before retiring to bed, is also good. This last induces a peaceful frame of mind which is conducive to restful sleep. One of the minor though not unimportant advantages of breast-feeding to the mother consists in the fact that she must stay quiet for from ten to fifteen minutes for feeding several times a day. These short intervals of compulsory rest are good for her both mentally and physically. Most people realize how rest will alter the outlook : the rather worried persons with a feeling of hurry driving them from behind lose their agitation on taking a short rest, especially if the rest be accompanied by some quite mild mental diversion. The tired muscles and the anxious mind of the person who worries relax if they can be persuaded to take rest. Too often, unfortunately, they are just the people who cannot appreciate the absolute need for both mental and physical repose.

Some pet hobby, if it be not exaggerated so as to become a nuisance to others, is to be encouraged. Life is dreary indeed for those who are deprived of their daily work by advancing years or ill health and who have no special interest in life. In the absence of family interests many retired persons fall a ready victim to indeterminate maladies when the real disease is that of boredom.

It should not be forgotten that there is a definite limit of capacity for work for each person, and that beyond that limit the efficiency of the work done decreases very rapidly, so that it may almost be valueless. Students or others who have relatively short intervals of intensive work are apt to think that the number of hours' work they do is a criterion of the amount of work done or of knowledge gained. This is far from being the case. One hour of real mental concentration on the subject in hand is of far greater value than three hours when fatigue has already supervened. The student starts with the idea that three hours' work is to be done, and the mental effort is in consequence reduced at the start. Later bodily fatigue intervenes, especially at night, and the mental effort, although perhaps as great as in the first instance, accomplishes little or nothing of any value. For purposes of systematic study, relatively short periods of full mental concentration are better and infinitely more effective than more prolonged periods, which will be accompanied by both bodily and mental fatigue in all but a few exceptional individuals.

Sleep is indispensable to life ; without sleep we cannot live. During normal sleep the body is released from the influence of the mind, and is free to carry out the recuperation needed without interference. There is more in sleep than mere rest of the body. Everyone knows that eight hours' lying still is not at all the same as eight hours' quiet sleep. Many attractive and even beautiful suggestions have been put forward as to what happens to the mind during sleep. Physiological sleep is dreamless, and the state of the mind in this condition is not known. The theories above referred to mostly relate to dreams or to a

partly awakened state, and are outside the province of this book.

During sleep the rate of flow of the blood in the brain is reduced, and the arteries are contracted ; those of the skin, however, dilate, and more water vapour is given off. There is an increase in the amount of oxygen taken in, and a decrease in the carbon dioxide given off [1]; these facts are consistent only with some altered or special phase of metabolism. The body requires to be kept warm during sleep on account of the dilatation of the vessels of the skin. The face and nose should be uncovered so as to enable the required oxygen to be absorbed. For the same reason the air of a bedroom should always be fresh, and there should be continuous ventilation during the night. Sleep is much more refreshing when the window is left open, and those who have once tried it are often hardly able to sleep with closed windows. Some modification of the degree of ventilation may be necessary with changes in the weather and in the temperature, although the last can also be met by increasing the warmth of the bedding and bedclothes. The really poor are often unable to afford this, and, in order to keep warm, they close the windows and block up all places where the cold air can possibly enter. This is far from conducive to good health, and the loss of good, refreshing sleep hinders development and impairs health. There is no advantage in very heavy sleep, from which, especially in badly ventilated rooms, less refreshment may be obtained than from a lighter but calmer sleep.

A heavy meal should not be taken just before going to bed. It is liable to cause sleeplessness or troubled sleep with distressing dreams. The nightmares of children are often traceable to this or to some form of digestive trouble. A warm, light meal of readily digested food may help to produce sleep by reducing the circulation in the brain and increasing that of the stomach. This is the reason why a feeling of sleepiness is so common after a meal, especially

[1] Pettenkoffer and Voit, *Sitzungsber d. k. baier. acad.*, 1866-7, quoted by Manaceine ; *Sleep*, 1897, p. 8.

when bodily fatigue is also present. Excitement or over-exertion often drives sleep away, the former because the brain is working and prevents sleep. A satisfactory explanation of the latter has not as yet been put forward, but it is a well-known fact, and must be reckoned with.

Sleeplessness is not infrequently due to some part of the body being cold. The feet are most often the primary cause, but some people with warm feet secure sleep by applying warmth to the abdomen ; this can be done by folding the arms over the body, if these latter are warm, or by a hot bottle. The feet can be warmed either by a hot bottle or by putting them in hot water for a few minutes before getting into bed, and drying with smart rubbing. With some people change of posture acts as an aid to sleep, or alteration in the level of the head, a glass of hot milk and water, or of milk, the nibbling of a biscuit, or a conscious relaxation of the muscles of the body may induce the sleep which does not come readily.

Where life is carried out in conformity with the general laws of hygiene, and sleeplessness persists, medical advice should be sought. Drugs to secure sleep should only be taken on medical advice.

The duration of sleep is largely a matter of habit. It is quite possible for sleep to be unduly prolonged, with consequent supervention of lethargic habits and indolence both of mind and body. Conversely, sleep can also be unduly curtailed.

There are a number of cases of celebrated men whose habit it has been to sleep for a few hours only. Doubtless there are exceptional people who can do with less sleep than others, but the ordinary individual will do well to take seven or eight hours' sleep.

Some of those who have written on the subject consider that the length of night and day should be determined by the sun. In agricultural districts and among the working population, this is necessarily very largely the case, and is probably sound both from physiological and hygienic aspects. But in towns it would be difficult to adopt, and

there is no evidence to show that, if ordinary precautions are observed, there is any detriment in working after darkness has set in, or in rising before the day has broken. There are, at any rate, many other factors in town life which are far more detrimental to health. On the other hand, the fresh air of the early morning in the spring and summer is wonderfully revivifying, and it is astonishing that so many people living in the country or in country towns are content to miss them by remaining in bed until the usual hour of rising all the year round.

Children require much more sleep than adults. They are not capable of the exertion of so long a day, and they require longer rest. They are growing as well as recuperating, and more sleep is necessary. The town-bred child, whose bedroom accommodation is frequently scanty, is often given too short a night. Insufficient sleep is a not uncommon cause of stunted growth or of poor development, and should not be forgotten in making inquiries about a child whose progress is not satisfactory.

It is impossible to lay down any precise rules which should govern the hours of sleep of children. The newly-born infant at first sleeps practically all day, later it has intervals of waking. Sleeping and feeding, etc., will, however, occupy a great part of the twenty-four hours during the early months of life, but the persistent rocking in order to get a child off to sleep again without appreciable waking intervals is not to be recommended. The healthy child can profitably be quiet and awake, and will learn to amuse itself quite well. Some attention from its family is good for it, while over-attention is as bad or perhaps worse than lack of attention. The repeated monotonous movements of rocking in a cradle do bring about sleep, so do also those made when the child is held in the arms to make it sleep. Both are artificial, and the child readily gets into the habit of sleeping only when these tricks are resorted to. It is bad for its nervous system to be rocked, and it should be allowed to sleep naturally and quietly. With advancing age the child will not want to sleep during the day, although

if laid down to sleep in a comfortable position after the midday meal, it will usually sleep well for a short time, up to three or four years of age. Children should not be allowed to sleep in awkward positions, such as are not infrequently seen in poor areas. The child sleeps leaning half out of a little cart, or leaning forward out of its chair over the table. These and other similar positions hamper respiration, and do not admit of satisfactory relaxation of the muscles. The child should sleep with its full length on the bed, either on its back or sides, according as it prefers. The duration of sleep can be gradually shortened, but for most children ten to eleven hours' sleep is advisable up to the age of about ten years. Eight hours should not be considered sufficient until young adult life has been reached at the age of about seventeen or eighteen. There will be considerable individual differences in the needs of children, and some modification in hours may also well be made to meet the changes in weather conditions in summer and winter.

Neither children nor adults should be awakened abruptly from sleep, unless this is unavoidable. The circulation in sleep is not in the same state as when awake, and time is required for its adaptation to waking conditions. The brain has to increase its rate of blood-flow, and the supply to the other parts of the body has to be reduced. Brooks and Carroll [1] found that in normal individuals a fall in blood-pressure occurred during the early hours of sleep amounting to as much as 24 mm. of mercury. Three hours after awakening there was still an average drop of 12 mm. Disturbance of sleep delayed, but did not prevent the maximum fall, although frequent interruptions of sleep did do so. It would seem probable, therefore, that an important element in sleep is the fall of blood-pressure, since practical experience shows the advantage of uninterrupted sleep. Some people are badly upset by being suddenly awakened, and many whose profession renders them liable to be suddenly awakened will have experienced the indescribable feeling of physical misery associated with necessary rapid and sudden activity in the

[1] *Arch. Int. Med.*, Aug. 1914, quoted by Faught in *Blood Pressure*, p. 125.

early hours of the morning, especially if the weather be chilly. The temperature is lower at night and in the early morning, and the fall of the general blood-pressure during sleep will account for much of the discomfort of enforced sudden awakening to activity during these hours.

Recently McDougall and Smith [1] have shown that deprivation of sleep has a definite effect on efficiency. Slight deprivation may increase the efficiency, but, after sitting up for three successive nights, the efficiency showed a marked decline, which persisted for from sixteen to nineteen days. These observations confirm the experience well known to some people that their brain is more active when there is a slight degree of physical fatigue. They also show that the after-effects of fatigue persist for considerable periods, so that recuperation would appear to be a longer process than is often supposed.

[1] *Proceedings of the British Association, Physiological Section,* August 1920.

IT is essential for the maintenance of health that a consider-
able amount of water should be taken into the body each
day. All food-stuffs contain large amounts of water in their
composition, but more water is required than that taken
in as a part of the food. The amount of water required will
depend upon the climate, and will vary with the tempera-
ture of the day and with the amount of exercise taken. Water
vapour is continually being given off from both lungs and
skin, and must be replaced by the drinking of water.

An average amount of fluid required by an adult in this
climate is usually said to be 1,500 c.c., or about $2\frac{1}{2}$ pints per
day ; it will, however, vary considerably, as already stated.

Water, which is liked by many people, is generally found
to be rather insipid as the only beverage, and most nations
of the world have devised for themselves various fluids which
have a flavour, and which are used by them to provide the
necessary water, either wholly or in part. Many of the
fluids contain substances other than water of considerable
importance, so that, while supplying the necessary fluid,
they also have other general effects upon the body. For
the most part these substances are harmful if taken in more
than very small amounts, and their action must be regarded
as drug action.

It would be beyond the scope of this work to enter into a
discussion of the various fluids taken as beverages by the
various nations of the world, although this is a subject of
more interest than might perhaps be supposed. It must
suffice to consider the common beverages in use in this
country. These will be taken to include tea, coffee, cocoa,

milk, and alcoholic drinks of various kinds. It seems advisable to emphasize again the need for taking a sufficient quantity of fluid during the twenty-four hours. As a whole men probably drink relatively more fluid than women, who tend to take too little fluid. There is an idea that the taking of a sufficient amount of fluid will conduce to the formation of fat, an idea which appears to fill many women's minds with horror. It is difficult, however, to see how such an idea can have arisen, nor does there seem to be any ground whatever for this statement. Fat formation is derived from food, and not from beverages. The obesity which follows the taking of large amounts of alcoholic liquors is not due to the water in the liquors, but to the effects of the alcohol. There is nothing fattening in water taken in reasonable amounts ; but taken in excessive quantities it may produce some degree of debility.

Water taken in by the mouth is absorbed mainly from the small intestine, and is passed round to the tissues in the circulation. In proper amounts it flushes them, and helps to remove the solid waste products which are then discharged by the kidneys. If too little fluid is taken each day, the waste products may tend to accumulate, and, in any case, more work is thrown on the kidneys, which have then to secrete urine against a much higher pressure than should be necessary. Further, an insufficient water intake is not infrequently a source of trouble with the alimentary canal. Insufficient fluid intake may be the cause of some degree of constipation. Absorption of fluid takes place from the large bowel, and if the amount of fluid be insufficient, the proper action of the bowels in getting rid of waste materials may be hindered. The addition of water to the dietary will frequently relieve such a condition, especially in infants and young children. Too often the amount of fluid taken by the mouth consists of a cup of tea at breakfast, a sip or two of water at lunch, one or two small cups of tea at tea-time, and a few sips of water in the evening—a total intake of (probably) about 1 pint instead of the $2\frac{1}{2}$ pints required.

The beverages above mentioned, which are to be considered in this chapter, fall into three headings, according as they have nutritive properties or not, viz. :

1. Cocoa, milk—have definite nutritive value.
2. Tea, coffee—have no value as food-stuffs.
3. Alcoholic liquors—may, in certain special circumstances, be regarded as having some nutritive value.

The fluids of groups 2 and 3 have stimulating properties, but their actions are different, both in nature and intensity. Those of group 1 have no direct stimulating properties apart from what may be due to their food value or to the conditions under which they are taken. A hot beverage is more stimulating than a cold one, because warmth is supplied to the body thereby, apart from any action of the substances in the liquid. Tea, coffee, and cocoa are usually provided hot, and in cold weather milk is often warmed before being taken.

Milk in this chapter is taken to be cow's milk, which contains about 11–12 per cent. of solid material. This is made up roughly as follows : protein, 3 per cent. ; sugar, 4·5–5 per cent.; fat, 3 per cent.; salts, 0·8 per cent.; and water, 87–88 per cent. Milk may therefore be regarded as a food, at any rate in some degree : it is the only food required by infants, and its value as a food-stuff for adults will be discussed in Chapter XIX. As a beverage it is very expensive at the present time, and must be regarded as a luxury rather than a necessity for all except infants. Cocoa contains fat, some of which is extracted in the process of manufacture of cocoa. This fat is known as cocoa-butter and became well known during the war, when fat shortage was acute. Cocoa or chocolate taken as a beverage usually receives additions in the form of sugar and milk, a good deal of both these ingredients being used by some people. When ready for consumption, therefore, it may contain a fair proportion of food-stuffs. A cup of cocoa may in effect be at least one-third milk, and, if made in the first instance with milk, may be

mainly milk, with the further addition of sugar and cocoa-butter. Thus it is comparatively rich in food-stuffs and is a nourishing beverage. Taken frequently, as above described, it would appear to have a tendency to produce the laying down of fat, which, however, may be merely due to the addition of this amount of food-stuffs to the dietary. The absence of any stimulating properties and the presence of nutritive substances make cocoa a very useful beverage for those needing to recuperate their powers. It is not as much used by poor persons as it might profitably be, on account, apparently, of its being given in prisons and workhouses, and has therefore become " tainted " in their minds.

In this country tea is more widely drunk than coffee, although the reverse is the case in most Continental countries. It is difficult to say why there should be this distinction; generally, however, Continental nations take more trouble over the preparation of their food than we do. Tea can be made and be a pleasant beverage with, as a whole, less trouble than coffee. Coffee needs grinding, and this must either be done at the home or it must be purchased ready ground at the shop. Ground coffee deteriorates rapidly in flavour, and to be nice must either be purchased at frequent intervals or ground for each occasion. Tea, on the other hand, if kept in a canister, preserves its flavour quite well, and requires no preliminary treatment. Again, as will be shown below, tea, as a whole, is a stronger beverage than coffee. The alcoholic liquors taken in this country, as beer, etc., are nearly all stronger than those taken on the Continent, so that there may be a general national tendency towards a heavier type of beverage. Also, tea is as a whole cheaper in this country than coffee. Tea and coffee both contain caffein or thein,[1] which when prepared separately is used as a drug. There is no constant percentage of caffein in either tea or coffee, the amount varying with the different varieties and qualities. An essential distinction between tea and coffee lies in the presence of tannin in tea, but not in coffee. The following

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[1] Both these names apply only to the one substance which is known commercially as caffein.

amounts of caffein and tannin have been found in dry tea-leaves before use :

	Black tea. Per cent.	Green tea. Per cent.
Caffein	3·2	2·3
Tannin	16·4	27·1

while the caffein in most coffee beans is said to amount to 0·8 per cent. only, and no tannin is present. These figures clearly give no indication of the amount of caffein and tannin taken in the actual beverages. A teaspoonful of tea may be taken to weigh 5 grammes, and 10–12 grammes of coffee roughly equal one dessertspoonful of ground coffee.

Smith [1] used 5 grammes of tea infused with 250 c.c. of water, or about a fair-sized teacupful. He found that approximately 98 per cent. of the caffein came out into the tea infusion, of which the greater part was found in the first 250 c.c. of boiling water poured on to the tea-leaves. The analysis of the tea-leaves gave :

	Caffein. Per cent.	Tannin. Per cent.
Ceylon tea	3·18	14·1
China ,, ...	2·60	13·78

The first infusion was allowed to stand for five minutes, was then poured off, and another 250 c.c. of boiling water was poured on. The infusions were analysed, and 100 c.c. contained the amounts shown below :

	Tannin in grammes.	Percentage of total tannin.	Caffein in grammes.	Percentage of total caffein.
Ceylon tea :				
First infusion . . .	0·199	70·5	0·055	86·5
Second ,, . . .	0·053	18·8	0·007	11·0
Total		89·3		97·5
China tea :				
First infusion . . .	0·151	54·7	0·040	76·9
Second ,, . . .	0·032	11·6	0·009	17·3
Total		66·3		94·2

[1] "Tea Infusions and their Constituents," *Pharmaceutical Journal and Pharmacist*, June 28, 1913.

These figures show that nearly all the caffein is extracted, of which by far the greater amount comes out in the first infusion. The same remarks apply to the tannin, but rather less markedly. Taking 3·2 as the percentage of caffein, 5 grammes of tea would contain 0·18 gramme. If several cups of tea be taken during the day, the amount of caffein taken becomes considerable, and will produce effects which are comparable to small doses of the drug itself. Rivers (see p. 175) was rendered markedly sleepless by ·5 gramme taken some hours before going to bed. Smith found that the hardness of the water did not affect the amount of caffein extracted, although it brought about some diminution of the tannin in the infusion. Some people in former days used sodium bicarbonate in the teapot with a view to reducing the hardness of the water or obtaining stronger tea. The sodium gives a darker colour, but does not affect the amount of caffein present.

Much evidently depends on the method of making both tea and coffee; namely, the amount of tea or coffee used, and the quantity of water. Coffee becomes blacker if boiled for a prolonged period, as also does tea if allowed to stand. There is very little precise evidence of the harmfulness or otherwise of the effects of prolonged standing or boiling. Generally, however, it may be taken that tea should be freshly made and used, and that coffee should only be boiled for a few minutes. It is probable that large amounts of tannin are prejudicial, since tannic acid precipitates protein and would therefore hamper digestion in the stomach. It is possible that this may have some connection with the indigestion often experienced by taking tea with a meal wherein protein forms an important part. Coffee rather than tea seems to be taken more usually with meals containing protein, and the custom is probably due to the action of tannin. It is well known that stewed tea is both unwholesome and disagreeable. Tea should be freshly made with water which has just come to the boil. The teapot should be previously warmed, so that the temperature of the water does not fall rapidly on being poured on to the leaves,

and the tea should not be allowed to stand for more than a few minutes. The teapot should be thoroughly cleaned, and its used leaves removed between each use. Tea should not be taken from a pot which has been left standing for a prolonged period on the hob.

The ground chicory root commonly added to ground coffee is innocuous : it is liked by some people and not by others. It makes the coffee look darker and therefore stronger. The really delicate flavour of the coffee bean is said by travellers to be unknown in this country—the best coffee being sent to or kept in Asia. It is also said that the best tea can be obtained only in the East.

It is now necessary to consider the effects of caffein on the system. A number of investigations have been carried out, especially on the effects of caffein as a drug. In these cases, however, the amounts used have often been in excess of that found in tea or coffee when used as a beverage, and are not, therefore, strictly applicable to the hygienic side. But a certain number of experiments on the effects of small doses, roughly comparable to the amounts contained in tea or coffee, have been carried out, notably by Rivers [1] and McDougall [2] in this country. [3] While certain differences were found between the various observers, as a whole the general results correspond very well. There would seem to be no doubt that caffein has a stimulating action and, up to a point, increases the capacity for muscular and mental work, especially when taken in small quantities. If taken in larger amounts, however, it seems to act as an accelerator of the onset of fatigue. With small doses, at any rate, there would appear to be no reaction after the stimulus. The results varied, however, with the person taking the liquid. [4]

[1] Rivers, *Influence of Alcohol, etc., on Fatigue*, published by Arnold, 1908.

[2] McDougall, *British Journal of Psychology*, 1905, vol. i, p. 442.

[3] The dose taken by Rivers and his collaborators was ·5 gramme, or about the equivalent of caffein in three flat teaspoonfuls of tea-leaves. (See above.)

[4] In one case no tea or coffee had been taken for two years before the experimental period, and the effects were much more marked than in the case of another investigator who had been taking moderate amounts right up to the experimental period.

Control mixtures were made up containing no caffein, and in which the taste could not be distinguished from that containing the caffein, and the person experimented on was not told which of the mixtures had been taken. The tests were carried out on an ergograph (for details cp. pp. 146 et seq.) to test the amount of muscular work done, also on a typewriter, and on McDougall's apparatus, where the experimenter has to hit dots passing through an aperture in front of him.

Roughly the same results were obtained by the different methods. The two last methods are primarily a test of mental work, and the ergograph of muscular work. It seems that caffein acts to some extent on the central nervous system as well as on the peripheral nerves, since there is an effect both in regard to mental and muscular work. As already pointed out, it is impossible actually to translate these experiments into terms of cups of tea or coffee, because great variation is experienced both in the variety of the tea or coffee used, and in the amounts taken to make the same quantity of the beverage ; also in the size of the cup used.

While tea or coffee in reasonable quantities and in reasonable strength two or even three times a day may not be injurious, it is evident that repeated draughts of strong tea or coffee must be detrimental. The central nervous system should not be stimulated artificially at frequent short intervals. In such cases caffein will exert its influence as an accelerator of fatigue. The habits acquired by some people, especially women, of drinking tea at intervals of every two or three hours during the day cannot be other than harmful and set up a vicious circle. Fatigue is induced by the continued administration of caffein as tea and coffee, and efforts are made to counteract this effect by taking further doses of the drug. Ultimately exhaustion and ill-health will supervene.

The key-note to personal hygiene is moderation in all things.

ALCOHOLIC LIQUORS

It is not proposed to enter here at any length into a discussion upon so-called temperance or intemperance. Common knowledge and observation alone are required to realize the horrible effects of excessive doses of alcohol. There is no need to expatiate upon the attendant evils of drunkenness to the person himself, or herself, and to those with whom they live, or to the community. This last bears the loss of labour and the cost of the ill health of the drunkard, or even of those who would not be considered as falling within so sad a category. It will presumably be admitted by all that alcohol, when taken in quantities sufficient to affect the outward behaviour of the individual, is detrimental both to the mind and to the body.

The question to be considered here is whether small doses of alcohol are detrimental, such as would be taken by those who, while never taking excessive amounts, habitually take some quantity of alcohol in the day. Before this can be dealt with, some general discussion of certain aspects of the question appears necessary. The alcohol now under consideration is ethylic alcohol, which has the chemical formula C_2H_5OH or C_2H_6O. It is formed by fermentation from a large variety of substances, and different methods are employed in its manufacture. Most nations, other than the very primitive ones, have devised some form of alcoholic liquors. Some of these contain large amounts of water, with relatively small amounts of alcohol, and so through all degrees of strength, until in some there is more alcohol than water. Each kind of liquor has a special flavour arising from the essential oils and other substances present in the fruit or grain, etc., from which the beverage has been manufactured.

The following figures give a rough idea of the amount of alcohol present in the commoner alcoholic drinks taken in this country :

Whisky	.	.
Rum	.	.
Gin	.	.
Strong liqueurs	.	

Formerly 50–60 per cent. alcohol ; now 30–40 per cent. alcohol by volume.

12

Brandy .	.	.	Formerly 43–47 per cent.; now 30–40 per cent. by volume.
Port wine	.	.	20–30 per cent. approximately, by volume.
Sherry .	.	.	16–22 ,, ,, ,, ,, ,,
Champagne .	.	.	10–13 ,, ,, ,, ,, ,,
Burgundy	.	.	
Hock .	.	.	8–12 ,, ,, ,, ,, ,,
Claret .	.	.	
Cider .	.	.	
Strong ale .	.	.	4–7 ,, ,, ,, ,, ,,
Stout .	.	.	
Light beer .	.	.	Up to 4 ,, ,, ,, ,, ,,
Porter .	.	.	

The strong spirits are usually taken diluted with water. A half-pint tumbler of whisky, which has been diluted with three times its volume of water, will still contain about $1\frac{1}{4}$ fluid ounces of pure alcohol, and the percentage of alcohol will still be higher than that found in the majority of wines, except port wine.

These figures are of some importance because the numerous experiments which have been carried out recently, and which will be considered below, are almost entirely based on cubic centimetres of pure alcohol and not on fluid ounces of wine.

It would be quite impossible in a work of this kind to make any attempt whatever to give an account of the immense mass of work which has been done on the subject of alcohol taken as a beverage. Although the investigations are apparently simple, there are many pitfalls. For instance, it is well known that some people are more susceptible to alcohol than others; again, a considerable amount of tolerance is established by those who habitually take alcoholic drinks, so that experiments conducted upon two individuals may not produce the same effect. Then there is the further question of the test to be employed, and the standard to be used, in determining the effect of taking alcohol. The difficulties will probably be more readily appreciated by considering the action of alcohol on the body. Taken into the stomach, the general effect of alcohol is to produce an initial stimulus to the heart and to cause a dilatation of the vessels of the skin · this last appears to be a specific action. The effect is to cause a sensation of warmth, since the sensa-

tions of warmth or cold depend upon the differences of temperature between the skin and the inner part of the body (cp. p. 54). Alcohol is probably absorbed only in small amounts from the stomach, and mainly from the small intestine. The rate of absorption varies markedly under different circumstances, notably according as the alcohol is taken fasting or with food, which retards absorption (cp. Reports 31 and 34 of the Medical Research Council and tables below), and also with the food taken. The presence of fat in the food further retards the passage of alcohol into the blood. Alcohol would appear to undergo no change in the alimentary canal, but to be absorbed directly into the blood-stream and thus carried round to all parts of the body.

Taken in doses which cannot be regarded as sufficiently large to produce a condition even approaching to inebriety, it yet has effects on the central nervous system. The person who takes even small amounts of alcohol does so because he finds he " feels " better and generally happier. He would not take it unless he did, for alcohol is an expensive form of fluid, and with many people is an acquired taste. The troubles which had seemed serious seem less so under the influence of a little alcohol, and the individual becomes less critical both of himself and of others. His judgment is less clear, but he feels cheerier himself, and is under the impression that his abilities are sharpened ; presumably this is due to the fact that the edge of his critical faculties has been blunted.

Hence it arises that people think they work better and are in a better mental condition after taking alcohol. As a matter of fact, the reverse is the case, as has been found abundantly by numerous careful observers. The sensations of a person who takes alcohol are no guide to the true condition.

The stimulation gradually passes off and leaves the heart and system generally in a condition more exhausted than it was before.

It has been shown repeatedly that soldiers and others engaged in hard muscular effort have their capacity for work

impaired by taking the ordinary allowances of beer or other form of alcohol. They may be said to expend a greater amount of energy in performing the same amount of labour, or they may do less work in a given time ; they do not march long distances so readily as their fellows who take no alcohol.

The effect of alcohol on mental efficiency has been studied by Vernon and his collaborators.[1] Each experimenter was set a definite task with a typewriter, a machine with which all concerned were familiar, and one person used an adding machine. The chief points investigated were the rate of typing and the number of errors made, before and after taking alcohol. In some of the persons concerned there was a definite effect on the rate of typing, which was reduced ; in one case, however, there was no effect on the rate. But the effect on the number of errors made was quite definite, and pointed clearly to a detrimental effect of the alcohol. This is well shown by the table given below,[2] which also shows

Effects of alcohol taken with food at 7.5-7.25 p.m. Mean time at which typing was made.	Time taken.		Mistakes made.		Mean values.		Mistakes corrected to constant typing speed.
	Slow typing.	Fast typing.	Slow typing.	Fast typing.	Time.	Mistakes.	
30 c.c. alcohol (Feb. 14-20) 9.15 a.m.	119·3	112·0	0·7	3·4	115·6 ⎫	2·1	2·3
6.41 p.m.	119·0	108·1	0·7	2·8	113·6 ⎬ 114·6	1·8	1·6
9 p.m.	120·1	110·5	1·8	4·2	115·3	3·0	3·2
10.40 p.m.	12_·1	112·0	1·5	3·0	117·0	2·2	2·7
60 c.c. alcohol (Feb. 28- Mar. 6) 9.10 a.m	111·7	103·7	2·2	3·8	107·6 ⎫	3·0	3·2
6.38 p.m.	109·5	101·8	1·8	3·6	105·6 ⎬ 106·6	2·7	2·5
8.51 p.m.	111·4	105·4	4·3	5·6	108·4	5·0	5·4
10.42 p.m.	110·1	102·4	2·6	4·3	106·3	3·4	3·3
Effect of 30 c.c. alcohol at 5 p.m. on an empty stomach 4.50 p.m.	110·2	102·2	1·1	3·0	106·2	2·1	2·1
5.52 p.m.	115·5	108·1	3·1	5·5	111·8	4·3	5·5
7.6 p.m.	114·0	104·7	1·4	3·5	109·3	2·5	3·2
9.14 p.m.	115·8	106·0	1·3	3·3	110·9	2·3	3·3

[1] Report to the Medical Research Council, No. 34.
[2] Loc. cit., pp. 11 and 12.

the increased effect of alcohol taken without food.   The
results are shown graphically in fig. 39.

The greater effect of 60 c.c. over 30 c.c. of alcohol taken

FIG. 39.—Showing the effect on the time and errors of typing when alcohol is taken with food and without it.

(By permission of His Majesty's Stationery Office.)

with food is shown, and the effect lasts longer. It is of
importance to note that 30 c.c. alcohol taken without food
show a rather more marked result on the errors than 60 c.c.

taken with food; also, the effect supervenes more rapidly.
The maximum effect was found by other experiments to take
place about 30 minutes after taking 30 c.c. alcohol without
food and 40 minutes after 30 c.c. taken with food.   The
curve corresponds very closely with the percentage of alcohol
found in the blood in experiments carried out by Mellanby [1]
(see below).

Further, the nature of the food taken affects the rate of
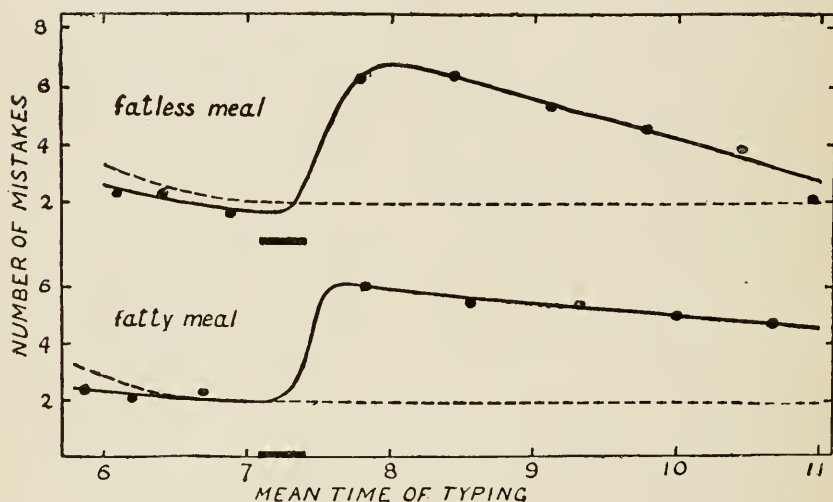
Fig. 40.—Showing the effect of alcohol taken with food, without and with
    fat.   Note the non-rapid rise and fall of the curve of the fatless meal.

(By permission of His Majesty's Stationery Office.)

absorption.   The number of mistakes made shows less
increase when fat is taken than without it.   On the other
hand, the duration of the period over which the increased
number of errors is made is very considerably prolonged ;
the curve shows that the errors made fall more slowly with
the fatty meal than with the fatless one.

The presence of the fat retards the absorption, spreading
out the period during which alcohol is entering the blood-

[1] Report to the Medical Research Council, No. 31.

stream ; the time of elimination of the alcohol is, therefore, of longer duration.

Fig. 40 shows this very well.   The actual figures obtained are not here reproduced.

It is interesting to compare the curves already given with the work of Mellanby on the concentration of alcohol in the
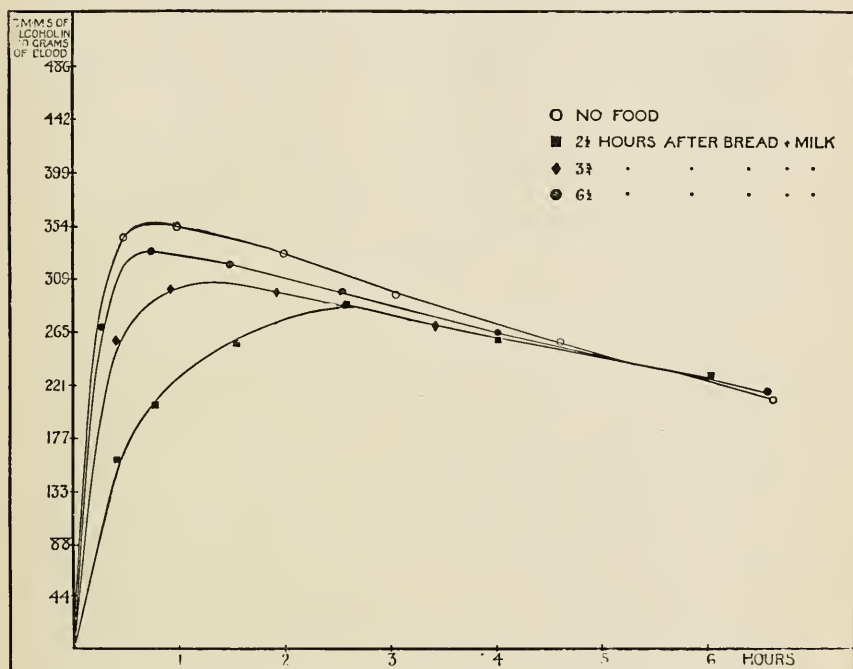
FIG. 41.—Showing the amount of alcohol in the blood when taken at various times in relation to food.

(By permission of His Majesty's Stationery Office.)

blood under similar conditions of food and without food. Mellanby's work was carried out on dogs.   Fig. 41 shows the effect of taking alcohol at different periods after a meal of bread and milk.   After $6\frac{1}{2}$ hours the stomach was presumably empty, and the results approximated to those found after the night's interval.[1]

[1] Medical Research Council Special Report Series, No. 31, p. 23, fig. viii.

Mellanby had also found that fat had an inhibitory effect on the absorption of alcohol.

In another case experiments with an adding machine were undertaken by an individual who was accustomed to take small doses of alcohol in the evenings, if so inclined. The figures in the table below [1] show the results of an experiment conducted over several weeks, both with and without alcohol. The smaller dose of 150 c.c. claret with food was found to have very little effect, but the increase to 190 c.c. without food showed a marked increase of errors made.

It may be noted that the 190 c.c. of claret with 19·4 c.c. of alcohol correspond closely as regards alcohol content with about one glass of port wine which was used in some of the experiments and found to contain 18·5 c.c. of pure alcohol.

No. of days on which experiments were made, and dates.	Time and conditions of experiments.	Mean time for two slow experiments.		Mean time for two fast experiments.		Mean of slow and fast experiments.	
		Time.	Errors.	Time.	Errors.	Time	Errors.
10 (May 11–21)	After lunch without alcohol	75·7	1·5	66·7	3·4	71·2	2·4
,,　　　,,	After tea without alcohol	76·0	1·4	67·7	5·5	71·8	3·4
6 (May 22–29)	After lunch, with 150 c.c. claret (= 15·3 c.c. alcohol) .	73·9	1·7	64·1	5·1	69·0	3·4
,,　　　,,	After tea without alcohol	72·3	2·3	62·4	3·7	67·4	3·0
5 (May 30– June 6)	After lunch without alcohol	75·6	1·4	64·2	3·8	69·9	2·6
,,　　　,,	After tea without alcohol	74·5	1·0	61·9	3·8	68·2	2·4
6 (June 7–14)	Early afternoon, ½ hr. after taking 190 c.c. claret (= 19·4 c.c. alcohol) without food .	71·1	2·0	62·4	7·2	55·8	4·6
,,　　　,,	After tea without alcohol	73·0	0·4	62·3	2·6	57·7	1·5
5 (June 17–21)	After lunch without alcohol	70·0	1·5	63·5	3·7	66·8	2·6
,,　　　,,	After tea without alcohol	68·0	0·5	62·0	3·0	65·0	1·8

[1] Medical Research Council Special Report, No. 34, p. 54.

In this table it is seen that there was a slight effect on the rate of adding, a longer time being taken to do the same piece of work—that is, the rate was reduced. The effect on the errors made is, however, again the most marked.

There is therefore abundant evidence that alcohol, even when taken in amounts comparable with that regarded as most reasonable for those who take alcohol at all, exercises a detrimental effect both on the general capacity for work and on the faculties. It can hardly be supposed that a continual effect such as is shown above can be without permanent detriment to the body generally. Anyone who will take the trouble to make observations will readily discover that the most alert people, who preserve the elasticity of their mind and body with advancing years, are those who do not habitually take alcohol. Those who early lose their muscular agility, and whose minds get set, will usually be found to take alcohol fairly habitually, although not necessarily in large amounts.

It is often contended that alcohol is a food, and that as such it should be beneficial. In the ordinary acceptation of the term, alcohol is not a food. At the same time, in certain circumstances it may have a certain food-value. Roughly, if there is already a sufficient dietary of other substances, alcohol does not act as a food; the tissues have enough fuel without the alcohol. If, however, for one reason or another an insufficient food-supply only is available, then alcohol can be used in small amounts as a food—that is to say, it can provide energy, but it is not available for building up tissue; rather, it is a tissue-sparer.

It is hardly possible to come to any other conclusion but that alcohol is a drug having harmful effects, and the wise person will keep away from it as from all other drugs unless ordered by a doctor.

CHAPTER XV

ON FOOD AND FEEDING

THE Great War brought the whole question of food into a prominence it had never previously possessed for the great majority of persons. The acute shortage of various foods and the complete disappearance of others from the market caused much thought to be given to it, both by individuals and by the scientific world.

Terrible experiments in nutrition on a gigantic scale have been witnessed among the nations of Central Europe, who have suffered nutritionally far worse than the Allies. No attempt will be made to cover the physiological side of nutrition, but no text-book on hygiene of the present type would be complete that did not give some information as to the way in which the various food-stuffs should be combined and eaten in order to preserve health.

Each nation has developed its own dishes and has certain special foods which are widely eaten. In most cases they represent some commodity which grows readily, or is readily obtained, in the country itself. For example, the fisher folk in Scandinavia or in the Shetland Isles live largely on fish, the natives of Malay on rice, etc. Where the climate is hard, the variety of food is generally restricted, the warmer and more favoured countries having at hand a larger number of food materials. Among primitive peoples many appear content with a very simple dietary, often most monotonous, rather than exert themselves to secure a more varied food-supply. In some countries the staple food substance is deficient in certain materials which we know to be necessary for the body, and in those countries diseases of special kinds are very prevalent. It is only

within the last twenty to thirty years that the causation of these diseases has been traced to a defective dietary. As a whole, it seems that the more prominent nations of the world have gradually widened the bases of their food supply, and take a mixed diet. This is very desirable, and the food-stuffs taken should be varied; but, in order to obtain the best results, some knowledge of the constitution of food-stuffs is necessary. Custom has in many cases found suitable mixtures in the way of dishes, or combinations of dishes, but there is still much to be desired in this direction among many sections and classes of the community in this country.

The general effect of feeding on health has long been realized, but proper attention to the food taken has been regarded as denoting greed, and it is also clear that ignorance still plays a large part in the unsatisfactory dietary of many. It is almost certain that a great deal of ill health both in adults and children is caused by an improper dietary rather than by an inadequate one.

This has been brought out very clearly by the work of physiologists during the last ten years. Although there is much that still requires further investigation, enough is known to form a valuable aid in arranging suitable dietaries. It may assist to a clear understanding of the position if some account is given of how the knowledge has been acquired, and of some of the experiments carried out. Physiology, as it is known at present, is of comparatively recent origin, but one of the subjects very early appreciated was the fact that food was the body's fuel. The body is continually giving off heat, and must get rid of heat, if life is to be carried on. The heat thus got rid of must be supplied from some source, and that source is the food. The food, after its entrance into the body, is broken down into smaller molecules, and these are absorbed before being utilized for the repair of tissue waste. In the process of being broken down and utilized heat is given off, and it is from this source that the energy necessary for life and activity is obtained. Hard work increases the heat given

off, and therefore increases the demand for energy and hence for food.

The amount of heat liberated varies widely with different food-stuffs : fats show the greatest amount of heat given off on combustion per gramme of weight. It might be supposed that the nature of the food-stuff was immaterial, if the necessary amount of heat were provided. This is, however, far from being the case. It has been realized for many years that health could not be maintained unless proteins (nitrogen-containing substances), fats, carbohydrates (sugars and starches), salts and water were taken in the dietary. Experiments have shown that to some extent the first three classes of food-stuffs are interchangeable. There must be a minimum intake of nitrogen, and this must be in the form of protein ; a part of the protein can, however, be transformed into sugar by the organism, and fats and carbohydrates can also be transposed. But there is a limit to the interchangeability, and a minimum quantity of all the above constituents must be supplied. Also, before the amount of each constituent falls so low as to approach the minimum, there is considerable loss, since the interchanging involves waste of energy.

The amount of heat given off by the various food-stuffs has been studied and is known, being measured in large calories, or the amount of heat required to raise 1,000 grammes of water through one degree Centigrade.

Rubner worked out " standard values," which are generally accepted for determining the average fuel value of dietaries and substances. These values are :

							Calories.
For each gramme of protein .	.	.	.	.	4·1
,, ,, ,, ,, fat .	.	.	.	.	9·3
,, ,, ,, ,, carbohydrate .	.	.	.	4·1

The amount of energy required will depend a great deal on the nature and amount of work done and upon the age and size of the individual. For an adult man doing average work, food-stuffs having a value of about 3,000 calories per day is generally regarded as necessary in this country.

The requirements of other persons have recently been worked out, and are given below (see p. 191).

Rubner showed many years ago that the loss of heat was in proportion to the surface of the body, and that the heat loss in the young was relatively greater than in the adult. Further, it must be remembered that energy is required for growth. Some very interesting work has been done on this question. It has been found that " the energy (calories) which is necessary to double the weight of the newborn of all species (except man) is the same per kilogram, no matter whether the animal grows quickly or slowly." [1] Some 4,800 calories is the figure required (approximately) for all animals except man, when the amount is six times as great. A certain proportion of energy contained in the food is retained for purposes of growth ; the precise proportion thus utilized will depend upon circumstances. If the animal is very active a larger proportion will be used in the work done, leaving a less amount for growth, which will thus be slower : the rate at which growth takes place depends upon the adjustment between growth and repair. If this is borne in mind the practical applications are very clear. Children should not be allowed to over-fatigue themselves, since this will require that an undue proportion of energy will be used for repair, and growth will be hindered. If it be argued that an extra food supply would admit of growth and repair after great exertion, it should be remembered that the stomach and intestines must also be considered, and that, if they are overtaxed, and especially under conditions of bodily fatigue, indigestion, with consequent malnutrition, will be the almost inevitable result. An interesting fact has been discovered by Rubner. He finds that each kilogram of adult body substance metabolizes an average of 191,600 calories before it becomes exhausted—that is, before death occurs. In the case of man this amount is much greater, being about 775,770 calories. The cells of the human body appear, therefore, to be capable of utilizing a much greater amount of energy than those of animals.

[1] Lusk, *The Science of Nutrition*, p. 414. Third Edition.

The amount of energy expended depends very largely on the amount of movement. It has been shown by several observers, that, if a child cries, the energy given off is greatly increased over that expended in the quiescent state. Investigations made on soldiers showed that even simple actions, like sewing on buttons, caused an increased output of energy, which, however, was less than that required for such actions as scrubbing floors.

There is a certain minimal amount of energy used up even though no active movements are undertaken. The heart and lungs and respiratory muscles are only still for very short intervals, and are using up fuel continuously. Hence, even a person lying in bed has need of food. The expenditure of energy when at rest is termed "basal metabolism." The increased metabolism when activity supervenes depends upon the action taken, and can be expressed in calories per square metre of body surface given off per hour. This figure for an adult man is about forty.

The increases in energy requirement with change of occupation have been given as—

Occupation.[1]	Increase in basal metabolism in per cent.
Sitting	5
Standing relaxed	10
,, hand on staff	11
,, leaning on support . . .	3
,, "attention"	14

All the available energy is not used directly in movement. All engines or apparatus using fuel show a heavy loss of the total energy, and in many cases the amount actually available is not more than 10 per cent. of the total amount. The proportion of energy actually used gives the "efficiency" of the machine. The body in favourable conditions may utilize 30 per cent. of the available energy.

Allowing for losses, and assuming an efficiency of 25 per

[1] *Report on the Food Requirements of Man and their Variations according to Age, Sex, Size, and Occupation.* Food (War) Committee of the Royal Society. Pub. by Harrison, March 1919, p. 2.

cent. and 39·7 calories per square metre of surface as
"basal," the following figures have been obtained [1]:

	Calories.
8 hours' sleep at 71·1 (basal metabolism) . . .	568·8
8 hours awake at 92·4 (basal metabolism + 30 per cent.)	739·2
8 hours' work [2] (basal metabolism + 240 × 4 = 568·8 + 960)	1528·8
	2836·8
Adding for locomotion and travelling	300·0
	3136·8

The proportion of calories required by persons of various
ages as compared with those required by an adult man have
been estimated by careful consideration of the requirements
for growth and of the body surface, and are given as follows [3]:

Both sexes.[1]						Coefficient.	Utilizable Calories.
0–6 years .	.	.	.	.	.	0·5	1,500
6–10 ,, .	.	.	.	.	.	0·6	1,800
10–13 ,, .	.	.	.	.	.	0·83	2,500
13–20 years (boys) .	.	.	.	.	.	1·0	3,000
Average man .	.	.	.	.	.	1·0	3,000
13–20 years (girls) .	.	.	.	.	.	0·83	2,500
Average woman .	.	.	.	.	.	0·83	2,500

Clearly the above are only averages, but they are of value
in giving the idea of the needs of the child during the years
of rapid growth.

A number of investigations have been carried out on
brain-workers, and it would appear that this class of work
does not call for an appreciable expenditure of energy. But
other considerations come in involving alterations in dietary
which is considered on page 197.

Our knowledge on many points connected with the energy
requirements is very incomplete and needs further investiga-
tion. The following charts will, however, be useful as giving

[1] Ibid., p. 4.

[2] As a result of certain calculations it has been assumed that the average
labourer will perform 102,000 kilogrammetres of work in 8 hours, which
will require the expenditure of 240 × 4 calories.

[3] *Report of Food (War) Committee*, p. 15.
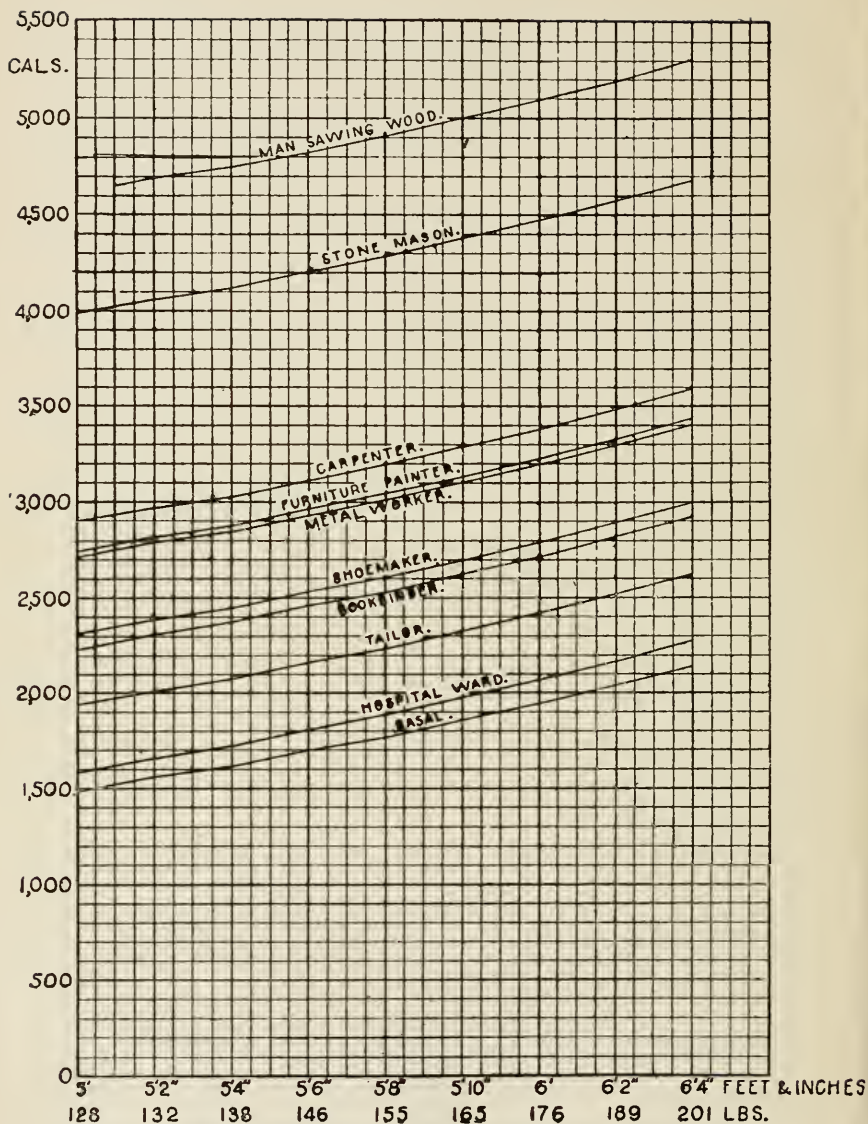
FIG. 42.—Metabolism in calories per day of men engaged for eight hours in various industrial pursuits.
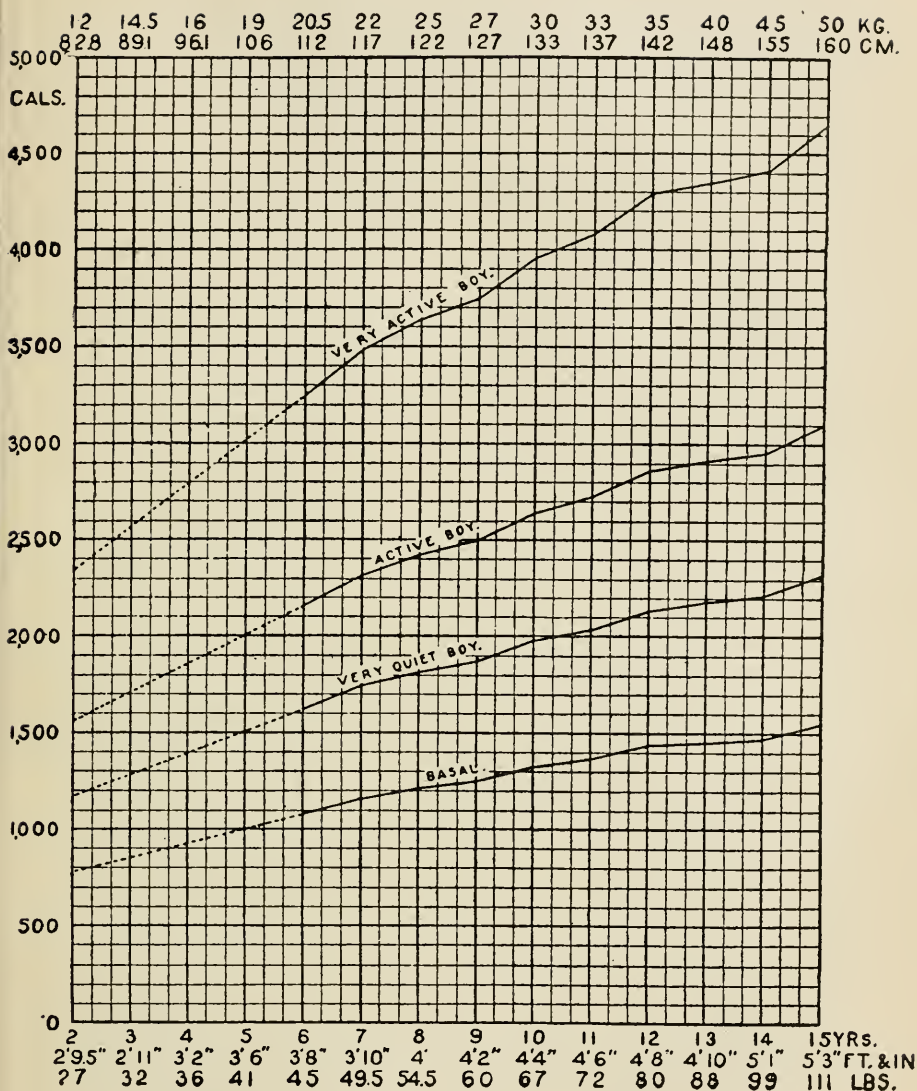
FIG. 43.—Metabolism in calories per day of boys from birth to 15 years of age.

some idea of the wide differences in output of energy and hence of energy requirements under different intensities of work by men or activity by boys.

Important as is the supply of the necessary energy to the body, it is only a part of the story of the needs of the organism. A dietary which is insufficient in caloric value will be inadequate and unsatisfactory, but a diet which is adequate as to caloric value may be wholly unsatisfactory from other standpoints, and be of a character on which life cannot be maintained.

There must be the admixture of food-stuffs already referred to in this chapter, and in addition accessory factors of food must be provided. In the following chapter these matters will be considered, but it will not be possible to give more than an outline of the position.

CHAPTER XVI

THE CHOICE OF FOOD-STUFFS

IN the preceding chapter it has been explained that a certain minimum amount of fuel is necessary for the repair and growth of the body and some idea of the amounts required has been given. In ordinary life, however, it is hardly possible to be mentally connecting the food-stuffs taken in with calories. This can be done at intervals if required, since the heat-value of the majority of common food-stuffs has been investigated and is known.

If the diet consisted of one or two food-stuffs the position would be very simple, and it would be possible to calculate and regulate the precise amount of energy taken in in the food. During the early months of life alone is only one article of food advisable, namely, milk. Later, after the first 8 or 9 months, a mixed dietary is necessary, and the reasons for this and the kinds of food which should be selected require consideration.

Physiologists and others are not as yet completely in agreement as to the extent to which the required energy must be obtained from the different classes of food-stuffs. All agree, however, that some portion of the diet must consist of protein in order that the necessary nitrogen shall be provided. Some one or more food-stuffs containing protein must therefore form a part of the diet.

The chief animal foods which contain protein are meat, including game of all kinds, fish, eggs, cheese and milk. All the ordinary vegetable food-stuffs contain a little protein, but

in very much smaller amounts per pound than is the case with animal foods.

The exception is the case of cereals where the total protein equals that found in some of the animal foods. But it is not enough that the mere quantity of protein should be taken. All proteins are not equally suitable for food, both on account of their composition and of the capacity or incapacity of the alimentary canal to make use of them.

Proteins are built up of a large number of bodies known as amino-acids. These acids contain the group NH_2, and it is this group which provides the nitrogen for the body. But the grouping of the nitrogen with the other atoms of carbon, oxygen, and hydrogen are of infinite variety, and each protein molecule contains not merely a great number of amino-acid radicles, but a great variety of the amino-acids themselves. It has been shown repeatedly by animal experiments that there are certain amino-acids which are essential to life, and which must be taken in in the diet. The complex protein molecule is broken down by the digestive processes and the amino-acids are liberated and absorbed. They then circulate in the blood-stream, and the tissues select the amino-acids they require. Certain organs need special radicles which they take up and utilize. A good example is that of an amino-acid termed tryptophane, which is almost certainly required by the thyroid gland for the performance of its functions. If this acid be not provided in the diet, then health suffers or disease supervenes.

Fortunately, although the proteins vary widely in their number of radicles of different acids, the majority of proteins contain the essential ones, although some food-stuffs are undoubtedly more suitable than others. Thus maize is deficient in two important acids, but it need not for this reason be regarded as an unsuitable food, only it must not be the sole source of protein. Taken together with other foods, it forms a valuable source of energy and of nitrogen. Again, gelatin is a protein, but it lacks three of the essential amino-acids. Hence, although digested, and its cleavage products absorbed, it fails to maintain life. A varied dietary ensures

the sufficiency of the needful amino-acids, since these are found, although in varying proportions, in the majority of proteins.

Protein has another effect on the body apart from its value as a source of fuel. It is a direct stimulator of metabolism, and brings about an increased heat production. This heat production is independent of the heat produced by muscular effort at the same time, and is a direct effect of the protein. Hence protein is said to have a " specific dynamic " action. This action is of considerable practical significance and should be properly understood by anyone making up dietaries. In a cold climate, where conditions of life may render it advisable for extra heat to be produced, protein is a valuable food-stuff. On the other hand, in hot climates, when the body has or may have considerable difficulty in getting rid of its heat, protein should be partaken of sparingly and primarily as a supply of nitrogen. The sedentary worker requires more protein than the manual worker. Thus persons whose employment prevents them from taking exercise and therefore from having an increased heat-production, are able on a rather full protein diet to maintain their body temperature without as much exercise as would otherwise be necessary. It must, however, not be supposed that a heavy protein diet replaces exercise for the body as a whole.

It appears, from the results of numerous investigations, that protein is not utilized for muscular work. Careful observations have shown no increase in the nitrogen output in the urine, even after severe bodily exercise. Except within certain narrow limits nitrogen is not stored in the body, but is either utilized or discarded. Man cannot live on a protein diet alone, although a dog can do so. A high or excessive protein content in the food results in retention of parts of the protein molecule other than those associated with the nitrogen atoms. It has been shown that there is considerable retention of carbon with a high protein dietary, and that this is probably stored in the body in the form of either glucose or glycogen. It is also possible that

fat may be derived from protein, but if this is so it is probably accomplished via the formation of glucose.

In practice, apart from the above considerations, a high protein dietary usually results in intestinal disturbances, and the health of the individual is affected thereby.

It is impossible to lay down a precise proportion of the total food which should consist of protein, since this will evidently vary with work and climate. Roughly, however, it seems probable that it should be about 70–80 grammes or $2\frac{1}{2}$–3 ozs. a day for the average man. The protein should not be all animal protein nor all vegetable protein, but a mixture. If a large proportion is taken as vegetable protein, then some authorities consider that not less than 100 grammes of protein should be taken per day, of which 30 grammes should be animal protein and 70 grammes vegetable protein.

Seventy to eighty grammes of protein would be contained approximately in any of the following [1] :—

> 2 lbs. bread,
> 1 lb. 2 ozs. meat,
> 10 ozs. cheese, or
> 10 eggs.

In practice in this country it is probable that the actual amounts of protein eaten would be considerably above these figures, and would be taken as to no less than one-half of it in bread, nearly one-half in animal food of one kind or another, and most of the remainder in cheese. Those who can afford it probably take well on towards $1\frac{1}{2}$–2 times the amount of protein actually needed. No special budgets for working-men alone apart from their families seem to have been made out, and such as have been investigated are usually taken from very poor families. The following may be regarded as being rather below than above the amounts taken by all working-men who can afford to pay for so much protein.

[1] *Report of the Food (War) Committee*, p. 18.

	Grammes weight.	Protein, per cent.	Grammes, protein.	Calories.
Breakfast :				
Porridge (1½ ozs. oatmeal)	43	13·4	5·6	= 23·0
Bacon (2 ozs.) . .	57	9·6	5·4	= 22·1
{ Egg (say 2 ozs.) . .	57	12·8	7·3	= 30·0
{ Or sausage (2 ozs.) .	(57)	(12·6)	(7·2)	= (29·5)
Bread (6 ozs.) . .	171	7·1	12·1	= 50·0 nearly
Main Meal :				
Meat (10 ozs.) . .	285	Say 13·0 (or at 15·0[1])	36·0 (41·6)	= 147·6 = (170·6)
Potatoes (8 ozs.) . .	228	1·9	4·5	= 18·4
Flour in pudding (4 ozs.).	112	10·0	11·2	= 46·0
Suet ,, ,, (count as fat)	—	—	—	—
Third Meal :				
Cheese (1 oz.) . .	28·5	25·1	7·1	= 29·1
Bread (10 ozs.) . .	285·0	7·1	20·2	= 82·8
			109·4	449·0

The above dietary is that allowed, as far as protein is concerned, by the Army. It is believed that it is often exceeded in the civilian population. The weight of meat and of cheese is probably on the low side for that which would be given at a meal by a good restaurant for working men, especially in works canteens. The figures are merely intended to give some idea of the form in which the daily protein is taken in by the average man. Taking figures of energy requirements of the Food (War) Committee (cp. p. 191), 56–64 grammes of protein would be required by a woman, or just about one-half of total amount of protein-containing food-stuffs as given above.

The bread as given above amounts to just over 6 lbs. a week, an amount very commonly eaten by a working-woman. It may also be mentioned that what would be sold as a good beefsteak for a working-man will weigh over ½ lb. and may easily reach 1 lb. or more. A small mutton chop will ordinarily weigh not less than 5 or 6 ozs. The weight of a " chop " may, however, easily reach 8 or

---

[1] If the meat is lean the protein content will be raised.

10 ozs. if of large size and thickly cut. In addition, the other adjuncts which are necessary in a complete dietary would supply further small amounts of protein. The food-stuffs taken for the above calculations will include materials such as fats and carbohydrates, salts and other food factors ; but the requirements of the body in regard to these are here temporarily disregarded. They are considered below.

If 4·1 calories per gramme be taken as the fair average for a protein in a mixed dietary, then 70–80 grammes of protein will yield 287–328 calories, or about $\frac{1}{10}$th of the total required. If as much as 109·4 grammes of protein be taken the calories will be 449·0, or just under $\frac{1}{6}$th of the total requirements.

It is theoretically possible to obtain all the protein required from vegetarian food-stuffs, but it is difficult to take sufficient to supply the body with nitrogen. The nitrogen must be present in a digestible form, and one which the organism can utilize fairly readily. For example, in vegetables, with their low protein content, a very great bulk must be taken in order to satisfy the needs of the body. The bulk may be so great that an individual accustomed to a varied dietary could not possibly eat it—the stomach and intestines could not deal with it. Again, it may be taken in a form so assimilable as to have little or no residue, as would be the case with milk. This again, while satisfactory from the point of view of theoretical metabolism, does not suit the alimentary canal, which is an important matter for the medical man and the hygienist. The need for a residue in the food is great, and is considered more fully in Chapter XVIII.

Fat is taken in part with the meat, and also in other vegetable and animal fats. The amount of fat varies greatly with the nature of the meat, and with the part of the animal from which it is derived. Certain parts constantly contain a higher proportion of fat than others. The percentage of fat in meat varies from 8 to 20, or even up to 30 for fat parts of mutton and pork. Eggs contain nearly as high a percentage of fat as of protein. Milk usually

contains 3 per cent., but the dairy products butter and cheese are very rich in fat. Butter is about 80 per cent. fat, and cheese about 32 per cent. Cream should contain from about 16 to 20 per cent. of fat. Fish is relatively poor in fat as compared with other animal foods ; the white fish, except halibut, contain almost negligible quantities, but a good deal is found in the coloured fishes such as salmon, herring, and mackerel. Butter has of late years been replaced in great measure by margarine, which is a mixture of vegetable and some animal fats (cp. p. 206). Dripping, lard, and suet contain only small quantities of any other substance than fat.

In addition to the fat eaten in meat and as butter or margarine, a not inconsiderable amount is used in cooking. For example, plain pastry and suet puddings contain not less than half as much fat as flour, although pastry is commonly regarded as mainly a carbohydrate food. Fat is also used in cakes in varying amounts, and is used in cooking in small quantities in a variety of other ways.

The Food (War) Committee suggests that 25 per cent. of the total energy requirements of the body should be taken as fat. It is not possible to state precisely the necessary amounts, since within limits fats and carbohydrates are interchangeable in the body, so that excess of the one variety will supply the deficiency of the other. Fat may be taken as providing on the average 9·3 calories per gramme. If 750 calories ($\frac{1}{4}$ of 3,000) may be regarded as a reasonable amount of energy to be provided by fats, then $\frac{750}{9·3}$ or 80 grammes of fat are required in the day—that is, 3 ozs. nearly (taking 28·5 grammes = 1 oz.). Experience has shown that the amount of fat may be increased with advantage when heavy work is being undertaken. Fat yields over twice as many calories per gramme as either protein or carbohydrate, and this forms a good food-stuff especially for work in cold weather or in cold climates. All vegetables contain a little fat, which in some of the cereals and pulses may amount to 2 or 3 per cent.

Before the war $\frac{1}{2}$ lb. of butter was reckoned as the ordinary requirement per head in a household for all purposes, including use for cooking, but not providing all the fat required, suet, dripping, and lard being available as well.

Taking the articles of diet already considered for the intake of protein, the following rough estimate of the total calories obtained from the fat can be made :

Food.	Amount.	Grammes.	Percentage of fat.	Grammes of fat.	Calories.
Rolled oats . .	$1\frac{1}{2}$ ozs.	42·7	6·6	2·8	= 26·04
Bacon . . .	2 ozs.	57·0	64·0	36·5	= 339·45
Egg . . .	2 ozs.	57·0	11·4	6·5	= 60·45
Meat . . .	10 ozs.	285·0	15·0 (approx.)	37·7	= 350·61
Suet pudding, one helping	$1\frac{1}{4}$ ozs. fat	35·6	75·0 (approx.)	27·0 (nearly)	= 251·1
	4 ozs. flour	114·0	1·4	1·6	= 14·88
Cheese. . .	1 oz.	28·5	32·0	9·1	= 84·63
Butter or margarine	1 oz.	28·5	80·0	22·8	= 212·04
				144·0	1339·2

In these articles of food the grammes of fat are found to be 144·0, or nearly twice as many as those estimated to be necessary. If the bacon is left out altogether and the butter reduced to $\frac{1}{2}$ oz. per diem the total is still in excess of the requirements. Taking the average amounts for a woman to be ·83 that for a man, the calories which should be obtained from fat would then be 622. The above amounts of food could therefore be reduced by more than one-half. Even so some of the fat energy could be made up by carbohydrates, so that a still further reduction would be permissible. During the war, when meat, bacon, lard, butter, and margarine were all strictly rationed, it is probable that the allowance of fat was down to, if not somewhat below, the minimal requirements, especially as all fats are not of equal value from the nutritional standpoint, apart from their energy value. The carbohydrate available was also restricted voluntarily, so that there was not full possible interchangeability.

Carbohydrates form a very important part of the dietary

in most countries. They are at once the cheapest form of food and are also the form in which energy required for muscular work is most readily made available. All cereals and pulses contain a high proportion of starch, which is converted into sugar (glucose) by the digestive juices. It can also be derived from protein by transformation in the body. Sugar is stored up in the liver and muscles in the form of glycogen, and is continually being used up in the course of muscular activity. The figure for energy value is the same as for protein, namely, 4·1 calories per gramme. Taking the total calories necessary at 3,000, of which 300 should be in protein, 750 in fat, then the remaining 1,750 calories have to be provided by carbohydrates. The manual worker probably takes the greater part of the calories in bread or flour and potato. One pound of bread yields 1,195 calories, and few manual workers will eat appreciably less than 1 lb. of bread a day. The remaining 555 calories will readily be made up on other foods. Seven pounds of potatoes in the week is not excessive for women doing domestic work, so that at least the same, namely, one pound per day, will almost certainly be taken by a man. This will yield over 400 calories. The remaining 150 will be more than made up in the use of sugar in tea or for cooking, flour in pastries, puddings, and cakes, and starch in vegetables, fruits, nuts, etc. The amount of carbohydrates in fruits is considerable, and in dried fruits may exceed 60 per cent., while in nuts it varies from 10–37 per cent., according to the variety. It seems probable that a large number of people take in a greater number of calories than is required. The brain-worker will usually eat less carbohydrate, since he does not require it for muscular energy.

Salts are also essential to life, and are present in all food-stuffs. The body requires a great variety both of basic and acid-radicles, but the precise quantity required is unknown. It is probable that vastly larger amounts of salts are taken in than are actually required. The nature of the salts differs in different food-stuffs. Some are deficient in one variety, others in another. Safety and sufficiency

of all kinds of salts is secured by a mixed dietary even at the expense of some waste and excess of the salts. Too much of any one kind of salt, if taken as a separate item, may readily be injurious, and a large amount of common salt in addition to the salts present in the food-stuffs themselves is not required. A little salt helps to bring out the flavour and to make the food palatable and is generally advisable ; but it is sometimes taken in excessive quantities at the table. Water is present in all food-stuffs in varying amounts, but there is not enough for the bodily needs, and fluid must be taken as a beverage (cp. Chapter XIV).

It seemed desirable to give some information as to the composition of the commoner food-stuffs, together with their caloric values and cost. Such figures were prepared by Lusk in relation to American food and food prices, but have not hitherto been available for England.

These have now been adapted by Professor Mottram, who has kindly allowed their publication (see below), together with an explanatory note written by him.

He says : " It is carefully to be understood that the following tables are intended as a guide to economy in dietary only, i.e. to show which foods are dear, and which cheap, as sources of (a) energy, (b) protein.

" The usual fundamental assumptions made in dietaries are :

> " (1) that a definite number of calories is essential per day, 3,000 for a man in a sedentary occupation, and 2,500 for a woman.
>
> " (2) that 30 grammes at least of animal protein with sufficient vegetable protein to make up altogether 100 grammes a day are essential.

" As regards these assumptions it may be stated that it is certain that some people can *exist* on a smaller caloric ration, and that further research may show that *some* vegetable proteins are as good as animal proteins. Already we know, e.g., that potato and pea-nut proteins are as good, or nearly as good, as cow milk proteins, but until research on the

distribution of amino-acids in proteins is more complete, until the biological value of the different proteins is more worked out, assumptions such as the above must hold the field. And not until strong, convincing proof from biological laboratories has been obtained to the contrary, dare we modify them. They are on the safe and conservative side.

"The costs, therefore, of obtaining 1,000 calories, or 30 grammes animal protein or 70 grammes vegetable protein, are the ones given.

"One word concerning the prices quoted is essential. They were collected in the neighbourhood of Campden Hill early in 1921. They represent in many cases ' rock-bottom' prices. Some since then have altered. But this alteration does not matter, for it is easy to recalculate the new figure. If ribs of beef rise from 1/6 a lb. to 2/-, the cost per 1,000 calories or 30 grammes of beef protein rises 33 per cent., 6d. being 33 per cent. of 1/6."

PERCENTAGE COMPOSITION OF COMMON FOOD-STUFFS AND COST OF 1,000 CALORIES AND PROTEIN RATION

	Waste.	Pro-tein.	Fat.	Carbo-hy-drates.	Cals. per lb.	Cost per lb.	Cost per 1,000 calories.	Cost protein ration (i.e 30 grammes).
Beef :								
Ribs	20·8	13·5	20·0	—	1,130	1/6	1/4	8¾d.
Round (lean)	8·1	18·9	6·9	—	675	,,	2/2¾	6¼d.
,, medium	7·2	18·4	12·2	—	895	,,	2/-	6½d.
,, fat	12·0	17·0	15·3	—	1,000	,,	1/6	7d.
Suet	—	4·6	77·7	—	3,440	,,	5¼d.	2/2
Atora	—	—	—	—	—	1/8½	—	—
Lamb :								
Leg	17·4	15·4	12·9	—	865	⎫	1/4¼	6d.
Shoulder	20·3	14·0	22·4	—	1,245	⎬ 1/2	11½d.	6½d.
Loin	14·8	15·5	22·9	—	1,295	⎭	10¾d.	6d.
Mutton :								
Leg	18·4	14·6	14·0	—	895	1/4-1/6	1/6-1/8	7¼-8¼d.
Loin	16·0	13·1	26·9	—	1,420	1/6	1/0¾	9d.
Shoulder	22·5	13·3	14·7	—	900	1/5	1/7	8½d.
Neck	27·4	11·9	17·0	—	970	1/3	1/1½	8¼d.
Pork :								
Loin	19·7	13·0	23·0	—	1,250	—	—	—
Smoked bacon	7·7	8·8	59·1	—	2,720	3/4	1/2¾	2/6
,, ham	13·6	13·8	31·7	—	1,640	—	—	—

	Waste.	Pro-tein.	Fat.	Carbo-hy-drates.	Cals. per lb.	Cost per lb.	Cost per 1 000 calories.	Cost protein ration (i.e. 30 grammes).
Fish :								
Cod	29·9	10·8	0·2	—	225	9d.	3/-	5½d.
Cod steak	9·2	16·5	0·5	—	350	10d.	2/4½	4d.
Haddock	51·0	8·1	0·2	—	170	—	—	—
Halibut	17·7	14·8	4·2	—	475	—	—	—
Mackerel	44·7	9·9	4·0	—	370	8d.–9d.	1/9½–2/1¼	5½d.–6d.
Sm. herring	44·4	19·9	8·4	—	760	10d.	1/-	3¼d.–3½d.
								Protein ration, 70 grammes.
Sugar	—	—	—	100	1,790	9d.–9½d.	5d.–5¼d.	—
Treacle	—	—	—	70	1,255	10d.	8d.	—
Maple sugar	—	—	—	71	1,270	—	—	—
Tapioca	—	0·1	—	88	1,685	10d.	6d.	} Cost pro-
Sago	—	1·4	—	78	1,665	10d.	6d.	} hibitive.
								Protein ration, 30 grammes.
Dairy foods :								
Eggs	11·2	11·5	8·8	—	615	3/- (8 to 1 lb.)	4/10½	1/8¾d.
Whole milk	—	3·2	3·8	5·0	310	4½d.	1/2	9½d.
Condensed milk	—	8·5	7·9	54·1	1,460	—	—	—
Cheese	—	25·1	32·0	2·4	1,885	1/8	10½d.	5¼d.
Butter	—	1·0	80·8	—	3,410	3/4	1/-	
Animal fat } Margarine }	—	1·2	78·9	—	3,315	1/6	6d.	} Cost pro-hibitive.
Vegetable fat } Margarine }	—	assume	the same			1/-	4d.	
								Protein ration, 70 grammes.
Cornflour meal, etc.	—	5–7	1·2	73–77	1625–50	10d.	6d.–6¼d.	2/7–1/10
Oatmeal	—	13·4	6·6	65·2	1,795	4d.	2¼d.	4¾d.
Rice	—	6·5	0·3	76·9	1,610	7½d.	4¾d.	1/5¾
Rye	—	5·3	0·8	76·9	1,610	—	—	—
Wholemeal	—	10·7	1·7	70·9	1,645	—	—	—
White flour	—	10·3	1·4	70·7	1,640	5/3 per 14 lbs.	2¾d.	6¾d.
,, (Highest quality)	—	8·7	0·9	73·6	1,620	—	—	—
Macaroni	—	10·4	0·8	73·0	1,640	1/-	7½d.	1/5¾
Spaghetti	—	9·4	0·4	75·1	1,640	1/-	7½d.	1/9¾
Bread, Brown	—	4·2	1·6	46·2	1,035	4d.	3¾d.	1/2¾
,, Graham	—	6·9	1·6	51·3	1,185	4d.	3½d.	8¾d.
,, White	—	7·1	1·2	52·3	1,195	3¾d.	3¼d.	8¼d.
Biscuits	—	Run	from	1850–	1920	1/4–1/10	8½d.–10½d.	—
Vegetables :								
Asparagus	—	1·3	0·2	3·3	95	2/6	26/4	26/6
Scarlet runner	7·0	1·7	0·3	7·2	180	—	—	—
White beans	—	15·8	1·6	59·9	1,530	3d.–6d.	2d.–4d.	3d.–6d.
Beets	20·0	1·0	0·1	7·4	160	3d.	1/6¾	3/10
Cabbage	15·0	1·1	0·2	4·7	115	3d.	2/2¼	3/6

	Waste.	Protein.	Fat.	Carbohydrates.	Cals. per lb.	Cost per lb.	Cost per 1,000 calories.	Cost protein ration (i.e. 70 grammes).
Vegetables :								
Carrots .	20·0	0·8	0·2	7·1	155	2d.	1/1	3/2½
Cauliflower .	—	1·3	0·5	4·7	135	4d.	2/6	3/11½
Celery . .	20·0	0·7	0·1	2·6	65	3d.	3/10	5/6½
Cucumber .	15·0	0·5	0·2	2·6	65	—	—	—
Lettuce .	15·0	0·7	0·2	2·5	70	—	—	—
Onions .	10·0	1·1	0·3	8·6	195	2d.–3d.	10¼d.–1/3½	2/4½–3/8¼
Parsnips .	20·0	1·0	0·4	10·4	230	2d.	8¾d.	2/7
Peas (dried)	—	17·3	0·9	62·5	1,580	6d.	3¾d.	5½d.
,, (green)	45·0	2·7	0·2	9·6	235	—	—	—
Potatoes .	20·0	1·3	0·1	14·2	295	2d.	6¾d.	1/11¾
Radishes .	30·0	0·7	0·1	3·9	90	—	—	—
Rhubarb .	40·0	0·3	0·4	2·1	60	—	—	—
Spinach .	—	1·6	0·3	3·2	100	6d.	5/–	3/4
Tomatoes .	—	0·7	0·4	3·8	100	10d.	8/4	18/4
Turnips .	30·0	0·7	0·1	5·5	120	1½d.	1/–	2/9
Fruits :								
Apples .	25	0·3	0·3	9·7	195	5d.–6d.	2/1¾–2/6¾	21/7–25/9
Bananas .	35	0·6	0·4	13·0	265	8d.	2/6	17/–
Blackberries .	—	1·0	0·9	9·9	235	—	—	—
Cherries .	5·0	0·7	0·7	14·4	305	—	—	—
Currants .	?	1·2	—	11·6	230	—	—	—
Figs (green) .	—	1·2	—	17·0	330	—	—	—
Grapes .	25·0	0·8	1·1	13·1	300	1/6	5/–	35/–
Bilberries .	—	0·5	0·5	14·9	300	—	—	—
Lemons .	30·0	0·5	0·4	5·4	125	4d.	2/8	10/3½
Oranges .	27·0	0·5	0·1	7·6	150	6d.	3/4	15/5½
Pears .	10·0	0·4	0·4	11·4	230	—	—	—
Plums .	5·0	0·7	—	17·3	325	—	—	—
Strawberries	5·0	0·7	0·5	6·4	150	1/–	6/8	21/3
Dried Fruits :								
Currants .	—	1·9	1·5	67·0	1,315	10d.	7¼d.	6/9¼
Dates . .	10·0	1·5	2·2	63·6	1,275	6d.	4¾d.	5/1¾
Figs .	—	3·4	0·3	67·0	1,290	10d.	7¾d.	3/9¾
Raisins .	10·0	1·8	2·7	61·8	1,270	1/–	9½d.	8/1¾
Prunes .	15·0	1·4	—	56·1	1,045	10d.	9½d.	9/2¼d.

COST OF 1,000 CALORIES

2d.–4d. Oatmeal, 2¼d. ; white flour, 2¾d. ; bread, 3¼d.–3¾d. ; haricot beans, 2d.–4d. ; dried peas, 3¾d.

4d.–6d. Vegetable margarine, 4d. ; dates, 4¾d. ; sugar, 5¼d. ; suet, 5¾d. ; animal margarine, 6d. ; tapioca and sago, 6d. ; cornflour, 6d.

6d.–8d. Potatoes, 6¾d. ; dried currants, 7¼d. ; spaghetti and macaroni, 7½d. ; figs, 7¾d. ; treacle, 8d.

8d.–10d. Biscuits, 8½d.–10½d. ; parsnips, 8¾d. ; raisins and prunes, 9½d.

10d.–1/–. Onions, 10¼d. ; cheese, 10½d. ; loin of Canterbury lamb, 10¾d. ; shoulder, 11¼d. ; butter, 1/– ; kippers and turnips, 1/–.

1/0–1/6. Loin of mutton, 1/0¾ ; carrots, 1/1 ; neck of mutton, 1/1½ ; milk, 1/2 ; bacon, 1/2¾ ; ribs of beef (lean), 1/4 ; leg of Canterbury lamb, 1/4¼ ; fat round of beef, 1/6 ; leg of mutton, 1/6.

1/6–2/–. Beets, 1/6¾ ; shoulder of mutton, 1/7 ; mackerel, 1/9½.

2/0–3/–. Moderately fat round of beef, 2/– ; ditto lean, 2/2¾ ; cod steaks, 2/4½ ; apples, 2/1¾–2/6¾ ; cabbage, 2/2¼ ; cauliflower and bananas, 2/6 ; lemons, 2/8.

At or above 3/–. Cod (whole), 3/– ; oranges, 3/4 ; celery, 3/10 ; eggs, 4/10½ ; grapes, 5/– ; strawberries, 6/8 ; tomatoes, 8/4 ; asparagus, 26/4.

Cost of 30 Grammes Animal or 70 Grammes Vegetable Protein

2d.–4d. Haricot beans, 3d. ; smoked herring, 3¼d.–3½d. ; cod steaks, 4d.

4d.–6d. Oatmeal, 4¾d. ; cheese, 5¼d. ; cod, 5½d. ; dried peas, 5½d. ; mackerel, 5½d.–6d. ; H. beans, 6d. ; leg and loin of lamb, 6d.

6d.–8d. Round of beef (lean), 6¼d. ; ditto medium, and shoulder of lamb, 6½d. ; white flour, 6¾d. ; round of beef (fat), 7d. ; leg of mutton, 7¼d.

8d.–10d. Mutton leg and neck, 8¼d. ; white bread, 8¼d. ; biscuits, 8¼d. ; shoulder, 8½d. ; ribs of beef, 8¾d. ; Graham bread, 8¾d. ; mutton (loin), 9d. ; milk, 9½d.

10d.–1/–. Biscuits, 10½d.

1/0–1/6. Brown bread, 1/2¾ ; rice and macaroni, 1/5¾.

1/6–2/–. Eggs, 1/8¾ ; spaghetti, 1/9¾ ; cornflour meal, 1/10 ; potatoes, 1/11¾.

2/0–3/0. Suet, 2/2 ; onions, 2/4½ ; bacon, 2/6 ; cornflour, 2/7 ; parsnips, 2/7 ; turnips, 2/9.

Above 3/–. Carrots, 3/2½ ; spinach, 3/4 ; cabbage, 3/6 ; onions, 3/8¼ ; dried figs, 3/9¾ ; beets, 3/10 ; cauliflower, 3/11½.

Above 5/–. Dried dates, 5/1¾ ; celery, 5/6½.

Above 6/–. Dried currants, 6/9¼d.

Above 8/–. Dried raisins, 8/1¼.

Above 9/–. Dried prunes, 9/2¼.

Above 10/–. Lemons, 10/3½.

Above 15/–. Oranges, 15/5½ ; bananas, 17/– ; tomatoes, 18/9.

Above 20/–. Apples, 21/7–25/9 ; strawberries, 21/3 ; grapes, 35/–.

CHAPTER XVII

FOOD AND FEEDING (*continued*)

ACCESSORY FOOD FACTORS

IT is now necessary to turn to another aspect of diets which has arisen during the last few years, following on the discovery of the occurrence of diseases when certain substances are deficient in the diet. These substances are termed vitamines, and, so far as is known at present, three separate varieties occur. The results obtained by experiment and the application of experimental results to men living under artificial conditions, such as is the case with armies and navies, have been almost dramatic in their success.

Seeing that we have recently passed through a terrible war, and that its effects are still rampant in certain parts of Europe, it is not surprising that there should have been a great deal both said and written on this subject. Before considering the attention which should be given to these bodies, it will be well to see what is known of them.

The first intimation of the importance of these bodies was obtained by the experiments of Hopkins,[1] who fed rats on a dietary of pure food-stuffs—namely, purified protein, carbohydrates, fats, salts, and water. The rats did not grow on this dietary ; but if so small an amount as 2 c.c. of milk was added, they grew normally. The remarkable differences in the increase of weight are shown in fig. 44.

The first one to be discovered was that now known as "fat-soluble A," or vitamine A. The term was given to it because it is found attached to fats. It would seem that the animal body cannot itself manufacture this substance, but must obtain it from plants, or from the flesh of another animal that lives upon plants. On the other hand, the seeds

[1] *Journal of Physiology*, 1912, vol. 44, p. 433.

of plants are, as a whole, not rich in fat-soluble A, although the amount varies with the grain. The germ of the grain appears to contain the major part. The vegetable oils and fats are poor in this body, and, curiously, lard, although an animal fat, is very poor in this substance.

The nature of this body is entirely unknown, and its presence or absence from any food or diet can only be
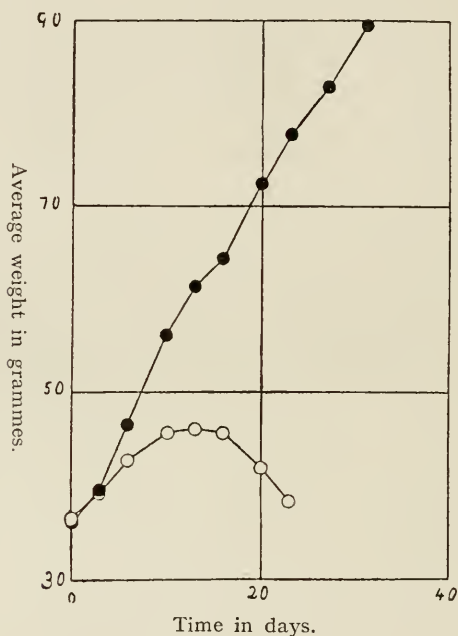
FIG. 44.—The lower curve shows the progress of six rats fed on artificial diet alone, and the upper one that of six similar rats fed on the same diet, with 2 c.c. of milk a day in addition.

determined by animal experiment. The effect of fat-soluble A is most marked in connection with growth, and, whatever body it may prove to be, is clearly an essential element in the promotion of growth. Young rats fed on a diet in which it is deficient do not grow, and will finally die, and children and puppies suffer in its absence. Adults, however, seem to require small amounts of this substance, but little is known precisely.

The appearance of animals fed on diets with and without
the vitamine A is also shown in fig. 45.

Similar experiments have now been carried out in great
numbers, both in this country and in America, and there
can be no question of the importance of the accessory food
factors. Mellanby,[1] working with dogs, has shown that if
fat-soluble A be not provided, the puppies become rickety.
The problem with dogs is, however, not quite so simple as
the above statement seems to suggest. A great deal
depends on the balancing of the food material in the dietary.
In all animal experiments it is unwise, and often incorrect,
to apply the results obtained, without modification, to the
human species. It cannot as yet be stated that rickets in

Fig. 45.—Showing the effect of feeding rats on dietaries without or
with vitamine A. (McCollum.)

children is produced by the absence of the body above
mentioned, although the addition of it to the dietary will
aid in effecting a cure. Cod-liver oil is rich in fat-soluble A,
and has for many years been used in cases of rickets (cp.
also Chapter XXVI). Its value was believed to be due to the
fact that it was a fat, but it was realized that other fats did
not answer the purpose so well. Fish fats are found to be
especially rich in this factor, which is presumably derived
from the sea flora and fauna eaten by the fishes, since it is
not believed that it is produced by the animal kingdom.

Milk has been extensively used in experiments for pro-
viding fat-soluble A in the diet, and, as a result, a great
demand has been made for the inclusion of milk as an

[1] Medical Research Council Report, No. 38, and other publications.

essential article of diet in the food of children. The occur-
rence of the accessory food factors, so far as is known at the
present time, is shown in the tables [1] at the end of this
chapter; and the question of their place in the feeding of
infants and children is discussed in later chapters.

This factor appears not to be destroyed by temperatures
ordinarily employed in the processes of cooking, although
it is destroyed gradually by prolonged heating, and rapidly
by oxidation.

A second vitamine is that known as water-soluble B, or
vitamine B. This body is attached to lactose in milk, and
is therefore left behind when the cream with its fat-soluble A
is removed. It is found almost universally and plentifully
in the vegetable kingdom, and is found also in animal food.
It is apparently obtained by animals from plants, as in the
case of fat-soluble A. A deficiency of this factor has been
shown to produce beri-beri in man, and poly-neuritis in
birds. The disease occurs in countries where the diet is
monotonous and is deficient in this factor. The well-known
case is that of the Malay Peninsula, where the inhabitants
eat polished rice as their main diet. The germ and the
layer of cells just inside the husk contain water-soluble B,
but these are removed in the process of polishing.

This food factor is believed to be resistant to heat as
ordinarily employed in cooking, but tends to be destroyed
in temperatures commonly used in the sterilization of tinned
foods. The universality of its distribution renders very
unlikely any shortage of it in an ordinary mixed dietary in
this country. The distribution of this factor in various
food-stuffs so far investigated is shown in the table at the
end of this chapter.

The third factor is that known as the anti-scorbutic factor,
or vitamine C. Scurvy is a disease which attracted atten-
tion in connection with prolonged sea-voyages of days gone
by, when the men were frequently away from land for
several weeks, and lived on dried foods. It is not possible
here to say more than that it was found that lime-juice,

[1] Taken from the Medical Research Council Report, No. 38, pp. 102–3.

made from Mediterranean limes, properly prepared, and given out as a part of the daily ration, completely prevented the occurrence of scurvy. Of recent years the study of scurvy has been taken up experimentally, and the war added impetus to the investigations. There have been many cases of scurvy in expeditions, or in camps where the conditions of the food-stuffs were unfavourable, and it is believed that the disease is due to the absence from the food, or to the destruction, of a special body which is present in large amounts in fresh fruits and vegetables. The nature of the body is unknown, and it has never been isolated. It is, in fact, apparently destroyed by desiccation, especially if the process be gradual. It seems to be less resistant to heat than the other factors, although little is known of its resistance to temperatures below 100° C. Nearly all the experimental work has been undertaken with material which has been heated for an hour at 100–120° C., temperatures not used in the ordinary household for prolonged periods. At the present time, as far as the usual mixed diet is concerned, it may be said that fresh or lightly cooked fruit and vegetables should form a part of any satisfactory dietary on account of the presence of this food factor. This has been realized on other grounds for many years. The question of this factor in infant feeding is considered in Chapter XXVII.

It is hoped that enough has been said to demonstrate the immense importance of a mixed dietary from the point of view of nutrition. Certain other features bearing on this are considered in Chapter XXVI.

It is not possible to deal with this complicated subject at any length, but, while recognizing its importance, the feeding experiments on animals should not lead to undue prominence being given to bodies of which very little is known. It is clear that a mixed dietary is essential, and that food should not be cooked longer than to render it safe from infection, or palatable to the individual.

The distribution of the three accessory factors in the commoner food-stuffs is shown in the following table:

Classes of food-stuffs.	Fat-soluble A, or anti-rachitic factor.	Water-soluble B, or anti-neuritic (anti-beri-beri) factor.	Anti-scorbutic factor.
Fats and oils :			
Butter	+ + +	o	—
Cream	+ +	o	—
Cod-liver oil	+ + +	o	—
Mutton fat	+ +	—	—
Beef fat or suet	+ +	—	—
Pea-nut or arachis oil	+	—	—
Lard	o	—	—
Olive oil	o	—	—
Cotton-seed oil	o	—	—
Coco-nut oil	o	—	—
Cocoa-butter	o	—	—
Linseed oil	o	—	—
Fish oil, whale oil, herring oil, etc..	+ +	—	— ·
Hardened fats, animal or vegetable origin	o	—	—
Margarine prepared from animal fat	Value in proportion to amount of animal fat contained	—	—
Margarine from vegetable fats or lard	o	—	—
Nut butters	+	—	—
Meat, fish, etc. :			
Lean meat (beef, mutton, etc.)	+	+	+
Liver	+ +	+ +	+
Kidneys	+ +	+	—
Heart	+ +	+	—
Brain	+	+ +	—
Sweetbreads	+	+ +	—
Fish, white	o	Very slight, if any	—
,, fat (salmon, herring, etc.)	+ +	Very slight, if any	—
,, roe	+	+ +	
Tinned meats	?	Very slight	o
Milk, cheese, etc. :			
Milk, cow's whole, raw	+ +	+	+
,, ,, skim	o	+	+
,, ,, dried whole	Less than + +	+	Less than +
,, ,, boiled whole	Undetermined	+	,, +
,, Condensed, sweetened	+	+	,, +
Cheese, whole milk	+	—	—
,, skim	o	—	—
Eggs :			
Fresh	+ +	+ + +	? o
Dried	+ +	+ + +	? o

Classes of food-stuffs.	Fat-soluble A, or anti-rachitic factor.	Water-soluble B, or anti-neuritic (anti-beri-beri) factor.	Anti-scorbutic factor.
Cereals, pulses, etc. :			
Wheat, maize, rice, whole grain	+	+	o
Ditto, germ	+ +	+ + +	o
Ditto, bran	o	+ +	o
White wheaten flour, pure cornflour, polished rice, etc.	o	o	o
Custard powders, egg substitutes, prepared from cereal products	o	o	o
Linseed, millet	+ +	+ +	o
Dried peas, lentils, etc.	—	+ +	o
Peaflour (kilned)	—	o	o
Soy beans, haricot beans	+	+ +	o
Germinated pulses or cereals	+	+ +	+ +
Vegetables and fruits :			
Cabbage, fresh	+ +	+	+ + +
,, ,, cooked	—	+	+
,, dried	+	+	Very slight
,, canned	—	—	,,
Swede, raw, expressed juice	—	—	+ + +
Lettuce	+ +	+	—
Spinach (dried)	+ +	+	—
Carrots, fresh raw	+	+	+
,, dried	Very slight	—	—
Beetroot, raw, expressed juice	—	—	Less than +
Potatoes, raw	+	+	—
,, cooked	—	—	+
Beans, fresh, scarlet runners, raw	—	—	+ +
Onions, cooked	—	—	+ (at least)
Lemon juice, fresh	—	—	+ + +
,, ,, preserved	—	—	+ +
Lime juice, fresh	—	—	+ +
,, ,, preserved	—	—	Very slight
Orange juice, fresh	—	—	+ + +
Raspberries	—	—	+ +
Apples	—	—	+
Bananas	+	+	Very slight
Tomatoes (canned)	—	—	+ +
Nuts	+	+ +	—
Miscellaneous :			
Yeast, dried	—	+ + +	—
,, extract and autolysed	?	+ + +	o
Meat extract	o	o	o
Malt extract	—	+ in some specimens	—
Beer	—	o	o

CHAPTER XVIII

THE HYGIENE OF THE ALIMENTARY CANAL

THE alimentary canal extends from the lips to the anus, and in the strict sense of the word may be regarded as lying outside the body; that is to say, although enclosed by the body, its contents always remain separated from the tissues by the walls of the canal, and never come into direct contact with any other part. Already in preceding chapters a great deal has been said about the importance of the food material which is supplied to the body, and it must be remembered that without the alimentary canal the food could not be made use of by the tissues.

The functions of the various parts of the canal are ordinarily regarded as routine matters to which each individual has become accustomed by the time that there is sufficient mental development to think. Too often attention is only devoted to the care of this important system when the absence of such care has produced a condition of illness in one or other part of this complex tract.

It is proposed in this chapter to consider in their order the several portions of the canal, and to mention their more important hygienic aspects.

The mouth and its organs are the first portion of the digestive system. It has in the main two functions to perform: the cutting or mashing up of the food taken—commonly called mastication—and the first stage in the digestion of starch.

The lips and teeth take hold of the food and pass it backwards into the buccal cavity. Here the muscles of the jaw cause the teeth to work on the food, and it is, or should be, bitten by the teeth into smaller pieces. Simultaneously the salivary glands begin to secrete actively, and saliva is

poured out, moistening the food and helping in its disintegration into smaller particles. The ferment ptyalin attacks the starch present in the food, and the first process of digestion begins.

The value of mastication is fairly well known, but it may sometimes be doubted whether its object is appreciated. The amount of mastication which can be carried out depends on the nature of the food supplied. Soft, pulpy puddings, etc., cannot be kept long in the mouth, but are automatically passed onwards to the next phase. Hard food requires prolonged mastication, and gives exercise to the muscles of the jaw, and is stated to be good for the teeth. It seems sometimes as if the words " tough " and " hard " were slightly confounded in the matter of food. There is no advantage, but the contrary, in tough food. The term denotes that the material is difficult to make any impression upon, and the muscles will be exhausted without producing much effect. Tough meat, for example, is very difficult to reduce to smaller pieces, and, unless cut up well before insertion into the mouth, will usually either be swallowed in fairly large pieces or be found impossible to deal with. On the other hand, hard food, such as thick biscuits or oatcakes, are capable of being broken up by cracking or by a process of attrition. For the most part it is foods which contain starch in considerable quantities which are hard, and it is precisely these upon which the saliva exercises its effect. The hard, starchy foods yield gradually to the pressure of the muscles, and are ground into small particles, which are in part digested in the mouth itself, owing to the longer period it remains there.

The development of the jaw and of its muscles must depend in some manner, at any rate, upon the amount of use given to the muscles while the jaw is in a state of growth. It is advisable that food which has to be broken up by mastication should be given as a part of the daily food, and attention should be devoted to the adequate chewing of foods such as meat and bread, which should be reduced to smaller pieces or to a pulp before being passed on to the stomach.

It is of importance that the teeth should be kept clean, and particles of food should not be allowed to lodge in the interstices, or to lie in the angles or corners of the mouth between the cheeks and the teeth. The condition of the teeth does not depend entirely upon the cleaning of them, although this is important. It is shown in Chapter XXVI that rickets affects the teeth. It has long been known that other constitutional diseases affect the structure of the teeth, and, as experience grows, it seems clear that the teeth are affected by any severe constitutional disturbance. Conversely, teeth which are neglected and allowed to remain in a dirty condition will affect the whole body. We do not at present know how to avoid the localized decay of the teeth, and the fact that some teeth will probably decay has to be faced. These spots of decay must be dealt with as soon as they arise. They may and will spread, not only in the tooth affected, but in the adjacent teeth. The process of decay produces substances which are detrimental to the body. These are swallowed and probably also absorbed through the sockets of the teeth into the circulatory system. Many serious conditions are caused by the presence in the mouth of decaying teeth. The gums may become infected, and pus may be poured out continually in small amounts. This is swallowed and causes disturbance in the stomach. Decaying teeth and a foul mouth must be regarded as a chronic sore, the discharge from which is swallowed or absorbed, and which sooner or later will affect the whole system, not infrequently leading to serious disease. The teeth should be cleaned not less frequently than once a day, and preferably twice. Some authorities advise that they should be cleaned after every meal, and, at any rate, care should be taken to dislodge particles of food which may be left behind after a meal. Various kinds of preparations are recommended for cleaning the teeth, but a simple material such as precipitated chalk will often be found to be as effective as the more expensive and elaborate powders and pastes.

Toothache should be treated by a visit to the dentist, and it will usually mean that the tooth required attention some

time earlier. Teeth do not ache unless the decay has
penetrated a fair distance. Acute pain may be due to an
abscess, which is not always caused by a decayed tooth.
It requires investigation without delay. Fortunately, of
recent years, the need for keeping the teeth in a healthy
state has been more widely realized, but further improve-
ment is still needed.

The far-reaching effects of bad teeth are well illustrated
by the work of Waller on nursing mothers. He shows that
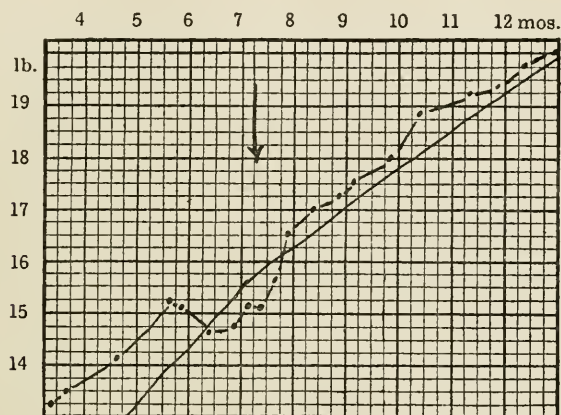
FIG. 46.—Showing the effect on the growth of the infant of removing
its mother's bad teeth. The arrow shows the point at which the operation
took place. The dotted line is the child's weight-curve and the straight
line the normal one.

the condition of the mother's teeth affects her general health
to such a degree as to affect the child she is nursing. How
far this effect is through the milk, and how far it may be due
to the contact by kissing, etc., with a foul mouth, cannot be
ascertained, but it is not difficult to suppose that both these
factors play a part. The increase in weight of the child
shown on the curve in fig. 46 shows the position in a forcible
and realistic manner. The food which is taken in contains
many bacteria, and the mouth itself has a rich flora varying
with the state in which it is kept by the possessor. Around

and connected with the mouth are aggregations of lymphatic glands, notably the tonsils and the tissue on the posterior wall of the pharynx, which take up and endeavour to deal with the bacteria which might otherwise gain access to the system. When children are allowed to suck dirty fingers or dummy teats which have fallen on the floor, and so on, additions are made to the bacteria in the mouth and to the work of the protecting glands. While there is no necessity to make any attempt to sterilize, it is well to exercise reasonable care and cleanliness with regard to what is put into the mouth.

The next part of the alimentary canal is the pharynx, which is also a part of the respiratory tract and is the place of crossing of the two systems, respiratory and alimentary. The respiratory passage, or larynx, now passes to the front, and the alimentary system, namely, the œsophagus, lies behind. The habit of speaking when eating leads to the opening of the larynx, with the consequent coughing due to a crumb or other material passing into the wrong system. The respiratory system endeavours to rid itself of the invading substance by the action of coughing.

The bolus of food when swallowed is gripped by the muscles of the pharynx and passed through the œsophagus into the stomach. The stomach is, in effect, an enlarged portion of the alimentary tube which has become altered so as to form a receptacle. It lies nearly horizontal in general direction in the adult, and the outer or lower part has a greater curvature than the upper and inner side. The walls are composed of layers of unstriped muscular tissue lined with mucous membrane of special type, which is different at either end. At both entrance and exit the muscular tissue is thickened to form a ring of tissue which closes the orifice, opening only in response to certain stimuli.

The gastric secretion is of the utmost importance in digestion. Its acidity destroys many of the bacteria in the food taken in, and the ferments act on the protein and fat, splitting them up into simpler bodies. Details can be found in any text-book of physiology. The stomach is capable of some

degree of distension, or of being partly filled without injury to it as an organ of digestion. Repeated overloading will bring about a permanent distension. When this occurs the functions of the stomach are impaired. It ceases to be able to empty itself properly into the next part of the canal, namely, the small intestine, and the products of digestion are allowed to remain stagnant. If the stomach, without being unduly distended at any time, is allowed no rest, it will sooner or later cease to carry out its functions satisfactorily. The habit of frequent meals or of eating between meals is very bad. The child who at short intervals eats sweets and cakes, the adult who takes bits of food incessantly, are injuring the stomach. This organ needs rest, like all the others, and must be allowed to clear up the duties connected with one meal, and have some rest, before being asked to undertake more work. If it be not given a rest it gets tired, and, like the individual himself, ceases to work efficiently. This leads to indigestion, the functions not being well carried out. An interval of not less than four hours should be allowed between any two solid meals, and a longer interval is preferable.

Food should be supplied to the stomach at fairly regular intervals and in reasonable quantities. The individual who eats in a haphazard manner—four meals one day and two the next—who is too busy or preoccupied to notice whether he or she is eating much or little, is rarely a very healthy person. The stomach does not like being treated in this fashion, but expects some consideration. No organ will work properly unless it is treated properly. Too often people do not realize this, and women especially are too apt to adopt the attitude of regarding the stomach as beneath serious consideration. "Anything," they say, "is good enough for me," and often they are so foolish as to carry this into practice. It is even considered as a triumph of mind over matter if a person appears to be relatively independent of the ordinary requirements of food. Sooner or later their health must suffer from it, for we cannot get away from the needs of the body. We may refuse to attend to the needs of the flesh, but

we cannot remove the need. Such practices lead to disease and not to health.

A line of distinction should be drawn between the attention that is necessary and that degree of consideration which becomes an indulgence of self. It is easy to pay an undue care to the arrangements for food, but some amount of thought should be devoted to it. Well cooked, appetising food is more easily taken and digested than badly cooked dishes without taste or, as it were, form. It may be that experiments with gastric juice shows no difference, but common sense and common experience cry aloud to the contrary and insist that there is a psychological side which does have an effect upon the general well-being. The importance of a properly balanced dietary should not be forgotten in framing the menu. Attention should be paid to the climate and weather, also to the conditions of work, etc. A person who comes in tired after the day's work should have some hot food, which will supply warmth to the wearied system. Cold food, however digestible it may be, must first of all be warmed in the stomach to the temperature of the body, and thus at first abstracts heat instead of supplying it.

In hot weather, when the need may be to get rid of heat, the natural tendency is towards cold foods, and especially to those which do not on combustion yield much heat or have no specific action in producing heat. For those who are working during the day it will usually be best to have the meal from which the most energy and waste will be derived in the middle of the day, and a nourishing but readily digestible one at night on return from work. A good deal must evidently depend upon the manner of life. The foreign plan of starting the day early and of taking a long midday pause is a very hygienic one, giving time to the body to recoup its wear and tear before proceeding to the second part of the day's work. ·

The amount of food eaten varies with the individual, and is in many cases largely the result of habit. The feeling of hunger is not an altogether reliable guide, being sometimes rather an indication of the recurrence of the time for a

daily habit rather than the expression of a need for food. Further, the feeling in regard to the need for the amount of food taken is often deceptive. The stomach gets accustomed to being filled with given amounts of food. Anyone can allow themselves to get into the habit of eating more or less than is reasonable, without noticing any particular change in themselves. There are wide limits of toleration, for a period, at any rate. If the limit in either direction is passed, then trouble comes, and the health suffers. There are many persons who habitually eat more than they really need, and who, if they are unable to obtain the amount to which they are accustomed, feel very hungry, when in fact it cannot be that they have not taken food sufficient in amount with which to carry on their work. But their stomach has been accustomed to a certain degree of distension, and the absence of this distension causes a feeling of hunger. Similarly, if a person who eats sparingly is required to eat more than usual, a feeling of distension is often complained of, although it is highly improbable that it arises from an actual distension of the organ.

The food which has been subjected to digestion in the stomach is passed out as it is ready into the small intestine. In the upper part the food now meets the bile, the pancreatic juice and the succus entericus, by the combined action of which the complex bodies are broken down into the simpler ones suitable for absorption. Absorption takes place freely from the extensive surface of the small intestine. Hygienically there is little to be said specially about this part of the alimentary canal. It will be clear, however, that upon it depends the health of the body, and, in order that it may supply the necessary bodies to the tissues, the proper food-stuffs must be taken by the individual. Fortunately, the body is able to deal with a certain amount of excess of the various food-stuffs. This safety mechanism should not be tried too far by the ingestion of a badly balanced diet, but should be aided by the knowledge of the needs of the body.

The food passes along twenty-two feet (approximately)

of small intestine, the digestible portions being broken down and absorbed during their passage. The material which reaches the next portion, the large intestine, is still in a semi-fluid state, and contains chiefly debris and bacteria. The large intestine commences in the right lower part of the abdomen and passes upwards towards the liver, then across the abdomen to the left side, where it turns downwards, and, after passing through the pelvis, reaches the anus. The chief functions of the large intestine are to absorb fluid so that the material presented to it is rendered more solid, and then to discharge this solid material, which is nearly all bacteria and waste, to the exterior. The food has, in fact, been overhauled and sorted into digestible and indigestible · the former has been absorbed, and the latter must be thrown out and got rid of. This latter process is just as necessary for health as is the former, but insufficient attention is often given to it. The large bowel must be kept in good condition, and for this purpose it must be relieved at suitable intervals of such of its contents as are finished with. The action of the bowel depends a good deal upon the amount of contents with which it is presented by the small intestine. As the fluid is absorbed, the material gradually accumulates in the lower part of the bowel and will slightly distend the walls. This distension stimulates the walls, and a general contraction takes place, leading to an expulsion of the contents. Such an expulsion should take place fairly frequently, not less than once a day. If the contents remain longer in the bowel, bacterial action produces abnormal products, which are absorbed and in time will poison the whole system.

Should an insufficient amount of material be present to produce a distension of the walls, the bowel will not empty itself, and the contents will remain in it too long. This occurs when the food is too nutritious, so that it is nearly all absorbed, leaving little or no residue to be passed into the large intestine. It also occurs if the food is too dry, so that the residue is hard, deficient in total bulk, and not

readily passed through. In such cases the bowel will not be emptied, and constipation will result.

The diet should contain a fair proportion of indigestible material, such as the cellulose of vegetables and of fruit, the husks of grain, etc.; it must not be too dry—that is to say, sufficient fluid must be taken, partly in the food and also separately as a beverage. Constipation both in infants and adults is not infrequently due to too small intake of water, and also to the nature of the food taken. The evils of constipation are not merely seen in a general state of ill health; it has recently been forcibly pointed out by Sir Arbuthnot Lane that the stasis acts detrimentally upon the bowel itself, leading to a variety of conditions which may ultimately affect life.

It is unwise to lay down too hard-and-fast rules as to the intervals which should elapse between the evacuations of the bowel, but it may safely be said that they should not be longer than about twenty-four hours. In many people the intervals are less than this, and a free natural clearance of the bowel is to be encouraged. Children should be taught that it is essential for time to be devoted daily to this purpose, and there is usually no difficulty in securing satisfactory habits if this is taken in hand from birth onwards. Neglect in children is often difficult to remedy later, and, apart from the bodily injury, the whole condition becomes a burden to the individual, and often also to those with whom they live.

Schools and educational institutions of all kinds should realize the fact that provision must be made for this necessary duty. Too often in the past, especially perhaps in girls' schools, inadequate accommodation and inadequate time have been allowed, rendering it impossible for the bowels to be attended to. Continual repression of the need leads to sluggishness of the bowel, and to constipation, with its accompanying ill health. Great improvements in sanitary accommodation have been made of recent years, but much is still required. All those who are responsible for others must learn to appreciate the necessity for adequate

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provision. The health of those for whom they are responsible is concerned, and due regard must be paid to it.

On the other hand, some people are unduly worried about the whole matter. This usually arises from some degree of constipation which has troubled them, and out of this they have got into the habit of taking drugs every two or three days. After a time, the bowel, having become accustomed to this artificial stimulus, ceases to work without it. Further, it requires an increasing strength of the stimulus, so that large doses of drugs must be taken. In many cases the bowel can regain its proper function if proper advice is obtained. In children it is fairly easy to secure good habits by giving decreasing doses of aperients each night. That is to say, the bowel receives a daily stimulus, but of a decreasing strength : gradually it will recover its own functions. It is perhaps well to mention that this should be accompanied by attention to the nature of the food and amounts of fluid, etc., already referred to. Exercise, by improving the general tone of the body, aids in the evacuation of the bowels, and should form part of the daily life of everyone. Fatigue, on the other hand, has the reverse tendency.

As in all matters relating to the hygiene of the individual, knowledge is required, and must be combined with common sense in its application.

CHAPTER XIX

OF recent years so much has been said and written about milk, some of which is partly erroneous, that it will be necessary to review the whole question in some detail. The position is not a straightforward one, but involves many issues. Too frequently one side only of the question is urged, and the other aspects are ignored, so that a false proportion is thus, perhaps accidentally, presented. Anyone who wishes to have a reasonably clear view of the present state of knowledge on the milk question must be prepared to expend a little mental energy, and to think about the various difficulties inherent in the whole problem.

Milk is produced by all varieties of mammals for the young of the species. Ordinarily the milk is secreted freely over such a period only as is required for the young of that particular species to become sufficiently mature to eat a more solid diet. The period necessary varies from a few days to a number of months, depending upon the state of maturity or immaturity of the young at birth, and also upon the rate of development after birth. The period of activity can be prolonged by continued stimulation of the gland.

For a varying period it is the only food required or suitable for the young of the species; but after a time the secretion ceases, and by that time the young animal should be able to eat the nourishment it requires.

So far as is known, the milk of all species shows certain fundamental similarities of chemical composition, and contains protein (the nitrogen-containing part), fat, sugar (carbohydrate), salts, and water. In addition, it contains substances apparently necessary for the carrying on of life

known as accessory food factors, or vitamines. In fact, it possesses all the elements required for food : this, however, is not identical with saying that it is a perfect food for anyone except infants or for the young animals for whom it was originally intended by nature.

Although the milk of different species contains the same constituents, the proportions of those substances vary widely in the different milks.

There is also a considerable variation in the composition of milk in each species, depending (in cows) upon the breed of cattle, the intervals between milking, the period of lactation, and, as regards certain factors, upon the food given.

Milk contains cells from the mammary glands. The milk from healthy, well-kept cows does not usually contain as many cells as that from cows not kept in a good state of health. In the early days of lactation there is always a great increase in the cells and in the protein content generally, and the term " colostrum " is given to this milk. The increased protein and cells render the milk thicker, and that from the cow is not commonly used as food by man, but is of special value for the offspring. The following figures give some idea of the composition of cow's milk and its variations :

	Per cent.
Water .	from 83–90
Fat .	,, 0·8–8·0
Caseinogen .	,, 2·0–4·5
Lact-albumin	,, 0·2–0·8
Lacto-globulin	,, 0·08–0·35
Lactose.	,, 3·0–6·0
Ash .	,, 0·6–0·9
Total protein.	,, 2·28–5·3

Nature of samples.	Proteins.	Fat.	Sugar.	Salts.	Water.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Cow's milk, average .	3·50	3·50	5·0	0·7	87
,, ,, 1st day of colostrum .	12·99	3·9	2·3	1·5	75
,, ,, 1st month of lactation	2·98	2·7	5·7	0·24	88
,, ,, Jerseys . . .	3·1	5·0	4·8	—	—
,, ,, Shorthorns . .	3·2	4·0	5·1	—	—
Human milk, average . . .	1·5	4·0	6·5	0·2	88
,, ,, 1st day of colostrum	9·7	2·6	2·9	0·4	87
,, ,, 1st month of lactation	2·9	2·7	5·7	0·2	88
,, ,, 8th month of lactation	1·7	3·3	6·3	0·15	—

The substances contained in milk must now be considered in greater detail.

Protein of Milk.—Cow's milk contains three different kinds of protein, which are termed caseinogen, lact-albumin, and lacto-globulin.

Caseinogen is present in combination with calcium, as calcium caseinogenate. It differs from the protein ordinarily taken in food in several ways, and does not appear to be found anywhere outside milk. Caseinogen forms ordinarily one-half to two-thirds of all protein in cow's milk. When milk is treated with rennet, the caseinogen alone is acted upon, being changed and afterwards known as "casein." Casein forms the substance of the clot when curds are made, but other constituents of the milk are caught in varying amounts in the meshes of the clot. Caseinogen forms only about one-third of the total protein of human milk.

Lact-albumin is an important protein. It has been shown to be identical with the albumin of the blood, and it is derived directly from the blood by filtration through the walls of the capillaries. It does not coagulate with rennet, but is found in the whey. Thus whey contains a considerable amount of protein, and the whey of cow's milk will contain little less protein than is found in full human milk. Infants fed on whey and cream obtain nearly as much protein as they would derive from their mother's milk, where the chief protein is lact-albumin.

Lacto-globulin is found in very small quantities, so small, in fact, that it has not always been detected by chemical analysis, but it can usually be demonstrated by more sensitive processes. It is derived directly from the blood, as is the lact-albumin, and is identical with the globulin of the blood. It carries with it the properties of immunity for the young of its own species, and is therefore of the highest physiological importance (cp. Chapter XXIII under Breast Feeding).

Sugar.—The sugar present in milk is called lactose, and is found nowhere else in the animal or vegetable kingdom, so far as is at present known. Lactose has the formula

$C_{12}H_{22}O_{11}$, being a disaccharide. It is manufactured by the cells of the mammary gland from the sugar circulating in the blood. This latter is glucose ($C_6H_{12}O_6$), and therefore the gland must be able to synthesize two molecules of glucose with the elimination of a molecule of water. This has not been accomplished in the laboratory, and the precise machinery whereby it is carried out is not known.

Lactose when taken by the mouth must be broken down into simpler molecules. Its cleavage produces two molecules of sugar, each of which has the chemical formula $C_6H_{12}O_6$, but the atoms are differently arranged in the molecules, giving rise to two different sugars, viz.:

$$C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6.$$
$$\text{Lactose.} \qquad \text{Glucose.} \qquad \text{Galactose.}$$
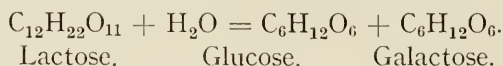
The alimentary canal of the young animal contains a ferment, lactase, which splits lactose in accordance with the above equation. This specific ferment disappears as the young animal becomes able to take varied food. The other ferments which attack sugar, and which appear later, are able to convert, at any rate, a certain amount of lactose; but lactose when taken in any large amount tends to produce diarrhœa. If injected into the blood-stream, it is excreted by the kidney. Lactose cannot be utilized as such by the body, but must be broken down and built up again, by the mammary gland if necessary. This is an important point, since nursing mothers are sometimes advised to take large quantities of milk, on the apparent assumption that it can be utilized directly, which is not the case. Lactose has no advantage over ordinary sugar for nursing mothers, although it has an advantage for very young children owing to the presence of the special ferment, lactase.

Fat.—The fat of milk is made up of a large number of different fats. It is not proposed to enter into any discussion of their varieties, since too little is known to make this worth while from a hygienic aspect. It is the fat with which is associated one of the vitamines (fat-soluble A), which has been shown in Chapter XVII to be essential for the

maintenance of health (cp. also Chapter XXVII).   It is known that the fats present differ both in amounts and in kind in different species, but nothing is known of the probable differences relating to the nature or amount of fat-soluble vitamines present in the different milks.

Great variations occur in the fat content of the milk at different stages of emptying the gland, either by milking, as in the cow, or by suckling in the case of the infant.   The first part of the milk is poor in fat, but the content gradually rises until the last portions of milk obtained may be extremely rich in fat.   Only insignificant and inconstant variations are found in the other constituents while the gland is being emptied.   Certain typical figures are given below :

								Per cent. of fat.
Human milk :	1st sample	.	.	.	.	.	4·4
,,	,,	2nd	,,	.	.	.	.	.	6·7
,,	,,	3rd	,,	.	.	.	.	.	8·4
,,	,,	4th	,,	.	.	.	.	.	10·3
,,	,,	5th	,,	.	.	.	.	.	10·5
Cows' milk :	1st half litre	.	.	.	.	.	3·7
,,	,,	3rd	,,	,,	.	.	.	.	.	4·2
,,	,,	5th	,,	,,	.	.	.	.	.	5·8
,,	,,	7th	,,	,,	.	.	.	.	.	9·3

The milk of cows has received different names according to the stage of milking at which it is obtained—the first portion is called " first milk," the last portions " strippings," and the middle portions " middle milk."   The strippings are usually many times richer in fat than the first milk, e.g. :

								Per cent. of fat.
First milk	.	.	.	.	.	.	.	0·55
Middle milk .	.	.	.	.	.	.	2·75
Strippings	.	.	.	.	.	.	.	8·30

These figures show the great importance of using samples of the whole of the milk, both for any purposes of investigation and for the feeding of infants.   In the case of human milk, it is evidently imperative that the child should empty the gland, otherwise the full fat content, and hence food value of the milk, will not be obtained (cp. Chapter XXIII).

Again, there is considerable variation in the fat content

due to intervals of milking. A long interval produces a
milk less rich in fat. Thus in winter, when the afternoon
milking is done early, the morning milk will usually show a
markedly lower fat content than the afternoon milk, although
the total yield may be larger; for example :

									Per cent. of fat.
6 hours after milking .		.	.	.	.	.	.	5·75
14 ,, ,, ,,		.	.	.	.	.	.	4·05
15 ,, ,, ,,		.	.	.	.	.	.	2·38

Also with breast feeding, when an eight-hourly interval is
allowed during the night, as against four-hourly ones during
the day, the amount of milk given is greater after the long
interval, but the fat content tends to be lower.

Salts.—The salts of milk have probably not as yet received
the attention they deserve. The total amount found varies
with the species, as also does the nature of the salts present.
Generally, the ash of milk contains calcium, magnesium, iron,
potassium, and sodium, which are combined in the milk
with a variety of acid radicles, as carbonates, sulphates,
chlorides, and phosphates. The phosphorus in the ash is
in part derived from the caseinogen, which contains phos-
phorus, and the association of calcium and caseinogen has
already been mentioned (cp. p. 229). Calcium is present
in larger amounts in cow's milk than in human, probably
on account of the difference in caseinogen already mentioned.
Iron is found in very small amounts in milk, but the body
is affected by very minute amounts of salts. Human milk
may roughly be said to contain from three to four times as
much iron as cow's milk. There is some evidence to show
that the iron in the milk of its own species is better utilized
by the infant than that contained in cow's milk. Water
forms about 87 per cent. of milk, leaving about 12 per cent.
for the total solid material. (For comparison with other
food-stuffs, see p. 205 et seq.) The accessory food factors have
never been isolated, and their nature is unknown as yet.
They are associated with the constituents of milk, but no
more precise information can be given at the present time.

While there are marked individual differences in the

composition of milk, as shown above, apart from these differences the composition is extraordinarily constant. Numerous attempts have been made to alter the composition by feeding experiments. While some modification in the quantity of milk can be effected by careful methods, and by increasing the food, none of the experiments so far published show that it is possible to obtain an increase in any one constituent of the fluid by the addition of that substance to the food. Thus work done with lactating animals and women by feeding on calcium, iron, sugar, etc., have either been inconclusive or have shown no effect whatever.

On the other hand, if any one vital constituent of the dietary is omitted, so soon as the deficiency is sufficient to prejudice the general health of the organism, then the whole milk supply fails. There is no reduction merely in the amount of that constituent in the milk, but a general reduction leading eventually to a cessation of the milk production of the gland. Within limits, therefore, a liberal diet may increase quantity, but, as will be shown later, excess of certain constituents may be prejudicial. The production of milk depends upon the general health of the organism, and the composition is regulated and kept constant by the gland itself.

CHAPTER XX

In the preceding chapter milk has been considered as to its chemical composition only. It is now necessary to consider it as an article of commerce, and to study some of the difficulties which arise in its production and its transport to the consumer. Milk, as it is found in the udder of a healthy cow, is free from bacteria. It is, however, only by exercising most stringent precautions, far too stringent to carry out in the usual routine, that milk can be collected free from contamination by bacteria. At every stage of its progress from the ducts of the gland to the consumer, milk tends to have its content of bacteria increased. The nature of the contamination differs at different stages, and it will be necessary to see why this is so. Many of the bacteria are not directly harmful, but when present in large numbers they produce effects which may be harmful, especially to infants.

The production of a milk free from bacteria may be regarded as a practical impossibility, but the gross contamination of the average sample of milk sold in this country is entirely unnecessary, and is the outcome of ignorance and carelessness on the part of those concerned in its production, coupled with ignorance and apathy on the part of the consumer.

It is not proposed in this chapter to discuss the position of milk as a food-stuff for either infants or adults. It is not material for the moment whether milk is or is not of importance as a beverage for adults. Milk is widely used for a variety of purposes in the ordinary household, and would be greatly missed if it were not available. But articles in

common use in the dietary should be as pure as is reasonably possible, since there is no advantage in consuming impurities, especially when, as in the case of milk, their origin evokes disgust, and they can be easily avoided. It is impossible to give any average figure for the number of bacteria commonly found in milk, owing to the wide variations. Roughly, however, it is fairly safe to say that the raw milk ordinarily sold in London, and many other large towns, contains several million bacteria per cubic centimetre. A cubic centimetre is just under seventeen minims, so that the quantity of fluid is small. If milk were a transparent fluid like water, such a sample would be cloudy in appearance, owing to the presence of these immense numbers of bacteria. As it is opaque, there is no difference in appearance whether the milk contains bacteria or not. The amount of sediment may give some kind of idea as to the degree of contamination, but cannot be regarded as a safe guide.

The first source of contamination to which the milk is liable is from the cow herself. The chief diseases from which many cows suffer, and which are known to affect the health of human beings, are tuberculosis and inflammation of the udder, or mastitis. It is also possible that other diseases of the udder from which they suffer may produce diphtheria and scarlet fever in man. These last, however, have only doubtfully been traced to the cow, and are not, for the present purpose, of the same importance as tuberculosis and mastitis. At the same time, the possibility of other diseases of the udder pathogenic to human beings increases the likelihood of the transmission of disease from the cow to man.

Tuberculosis is certainly the most serious infection, owing to the wide prevalence of the disease among cows. There are no figures which can supply an accurate statement as to the percentage of cows infected. Reliable authorities believe that 25 per cent. would be a conservative estimate, and it is stated that the figure might be a good deal higher. A cow may have tuberculosis of many parts of the body; the udder itself may or may

not be affected. Tubercle bacilli are frequently passed in the milk when the udder itself shows no sign of disease on physical examination.[1] It is not therefore safe to assume that the milk will not be infected unless the udder itself is infected. Indirect, if not direct, infection may also take place from a tuberculous cow, through the presence of tuberculosis in the alimentary canal. A cow with pulmonary tuberculosis will swallow tuberculous sputum, and the bacilli are excreted alive in the fæces. Any contamination of the milk by fæces would therefore be liable to infect the milk.[2] The practice of mixing milk from many cows on a farm disseminates the bacilli, if any are present, but it also reduces the mass of infected material in each portion of the milk, since it may be assumed that much of the milk will be free from tubercle bacilli.

The presence of tubercle bacilli in milk can only be accurately determined by injecting the suspected fluid into a guinea-pig. These animals are very susceptible to tubercle, and if killed from four to six weeks after the injection, will show the presence of tubercular lesions if the milk has contained tubercle bacilli. A very large number of tests are made each year in London and in other large towns in this country. There are naturally considerable variations in the figures obtained both from year to year and in different places. Generally, however, it may be said that the results show that from 6–8 per cent. or more of all samples examined contained tubercle bacilli.

There can no longer be any doubt that these bacilli are capable of infecting man. There has been much discussion of this point, and much experimental work has been carried out. The tubercle bacillus found in cattle (bovine tubercle bacillus) shows slightly different properties from the human bacillus. This renders it possible to determine the origin

[1] Délépine, " Report on the Prevalence and Sources of Tubercle Bacilli in Cow's Milk." Report of the M.O. to the L.G.B., 1908–9.

[2] It has recently been shown that the bacilli passed out with the fæces remain virulent for many months, and are capable of infecting other animals grazing in the field. Report of the Medical Research Council, 1920, p. 46.

of tuberculosis in man, if a sample of the infected tissue can be obtained. The Royal Commission on Tuberculosis [1] found that in young children dying from alimentary tuberculosis about 50 per cent. of the cases were due to the presence of the bovine bacillus alone. They further point out that there are an immense number of children whose health is damaged by tubercular lesions, but who do not die. More recently the great number of occult cases of tuberculosis in children has been demonstrated [2]—that is, when there was no clinical evidence whatever of tubercle, the child dying of some other complaint. In Edinburgh a great deal of work has been done on this point, demonstrating conclusively the ravages of the bovine bacillus. As an example, Mitchell [3] examined eighty consecutive cases of tubercular glands. He states that " without exception the cases were those of children twelve years of age and under. The maximum incidence occurred during the second year of life. This is not surprising when it is recalled that the large majority of children of this age are nourished in whole or in part on cow's milk. I found that in my series of cases, 84 per cent. of the children of two years and under had been fed with unsterilized cow's milk since birth. Whatever may be the case in other countries, the mode of feeding children in Britain, especially in Scotland, is such as to favour bovine infection."

Children as a whole are more often victims of tuberculosis of the bones, joints, and glands, than of tubercle of the lungs, and their lesions are frequently found to be due to the bovine bacillus. The Royal Commission state : " Although the bovine tubercle bacilli may, as it appears, be solely responsible for certain cases of pulmonary tuberculosis (consumption), and though it may be present with the human tubercle bacillus in the bronchial glands, it is evident from the data recorded that the majority of cases

[1] Final Report of the Royal Commission on Tuberculosis.

[2] Délépine, *British Journal of Tuberculosis*, 1920, vol. xiv, p. 60.

[3] " Bacteriological Study of Tuberculosis in the Lymph Glands of Children," *Journ. of State Med.*, 1915, xxiii. 1.

in which the bovine tubercle bacillus is the infective agent in the human being are cases of alimentary tuberculosis. Such are cases of cervical gland and primary abdominal tuberculosis. In the latter class of cases at least the tubercle bacillus has unquestionably been swallowed. . . . The percentage of these cases of alimentary tuberculosis due to the bovine tubercle bacillus is very large."

The only way in which it would be possible for a milk supply to be free from tubercle bacilli would be by eliminating the disease from cattle. This, however, while a most desirable object to bear in mind, is one of the utmost difficulty to carry out, and for all practical purposes at the present time must be regarded as almost impossible.

There is no difficulty in detecting tubercle by physical examination of the cows when the disease is well established. In the earlier stages it may be quite impossible to do so, although, as already mentioned, the cow may be passing the bacilli into the milk.

The tuberculin test is of great assistance in detecting tubercle when properly used. The principle employed is the injection of a known dose of tuberculin (prepared from dried tubercle bacilli) with a view to obtaining a reaction in the cow. If the cow is tuberculous, the temperature will rise a few hours after the injection. If the temperature remains approximately constant, the test is negative. Unfortunately, this test can only be applied at intervals of a few months. The cost of testing is considerable, and the whole procedure is upsetting to the work of the dairy. Further, there is some risk of the cows' reacting uncertainly to the test if it is applied at short intervals. It is true that much can be done towards reducing the likelihood of tuberculosis in a herd, by regular injection of the cows and immediate elimination of those found to be infected. Every new cow admitted must be excluded for some months from any contact with the others, and must be satisfactorily tested at the end of this period before being allowed to join the herd. It is not advisable to test her on admission, for various reasons which are beyond the scope of this book.

Dairy farmers who aim at a herd free from tuberculosis usually breed their own herds so far as may be, in order to avoid the risk of introducing infected cows from outside. It is important that a clear idea should be gained of this question of tuberculosis, for there is much loose talking which sounds impressive but which means little. For example, one large firm of milk-vendors at one time labelled all their milk carts " tuberculin-tested milk," which impressed the public and gave the impression that the milk was safe as regards tuberculosis. Actually the words mean nothing, for it is not possible to test milk with tuberculin, and the great difficulty of obtaining a herd guaranteed free from tuberculosis has been explained above.

Even in America, where milk production on a scientific basis has been carried out for a number of years, virulent tubercle bacilli have been found in milk which has been produced under the strictest regulations for the detection of tuberculosis in the herd. The possibility of the presence of bovine tubercle bacilli in any given sample of milk cannot be ruled out, with the present known methods. The subject is a complicated one and cannot be dealt with fully here.

Inflammation of the udder, or mastitis, is a not uncommon disease in cows: it is said that it is more common when the cows are badly cared for and kept in unhygienic conditions, but it will at times find its way into the best-kept herd. The organism which most frequently causes the trouble is a streptococcus, and many epidemics of septic sore throat have been traced to the occurrence of mastitis in one or more cows in the herd giving the milk which has been consumed. It may be that the affection is not discovered by the milker, or that the bacteria are passed out before any outward evidence is noticeable. Also, it is to be feared that the farmer is unwilling to throw away milk which, while he knows it to come from an unhealthy udder, is not as yet much altered in appearance, and which can quite well pass as good milk. If the mastitis is severe, the character of the milk alters, and blood and pus may be passed out with it. In this stage of the disease, the milk

would probably be drawn only to relieve the cow and would be thrown away.

In view of the above facts, it is clear that it is unsafe to regard any sample of milk as free from the germs of disease which may be derived from the cow. Clearly the majority of samples taken are free from such germs, but it is impossible to say which are and which are not. It is safer to act on the supposition that the milk is infected, and to take the precaution of heating the milk, as described in Chapter XXII.

There are, however, other sources of contamination of milk by the cow herself. Unless cows are kept scrupulously clean, the udder and hind quarters become soiled with excreta, and may even be caked with the dried material. In the process of milking, some of this is rubbed off by the milker. He not uncommonly puts his head against the cow's flank, and the movements made rub the dirt off the cow into the pail below.[1] The manipulation of the udder has the same result, and further contamination may be caused by the passage of urine or fæces during milking. Unless the greatest care is taken, bits of hair and epithelium from the cow's skin will be rubbed off and fall into the pail.

On a farm where the milk production is carried out on up-to-date lines, the cows' udders are clipped, so as to remove the hairs, and the hind quarters, udder and tail, are rubbed down with a clean, damp cloth, and then with a dry one before each milking, the skin being left moist but not wet. The milker is not allowed to put his head against the cows, and a special kind of pail is used which prevents the falling in of hairs, etc., from the cow. Two specimens of pails are shown in fig. 47. With the protected pail the milker holds the pail slightly tilted, and milks into the aperture at the side.

The milker is a further source of contamination. His hands are not always washed before milking, and he may come straight from carting manure to the milking. He

[1] This assumes that the pail is an open one, which will probably be the case where the cows are dirty and old-fashioned methods are employed.

may moisten his hands with saliva, and a not uncommon practice is to draw a little milk and then dip the hands into the pail to moisten them.

A milker should have hands which have been thoroughly washed with soap and water, and the nails must be kept short and clean.   After washing, he must not handle anything else except the cow's udder, which will have been previously cleaned as already described.   He should wear a clean, freshly-washed overall, covering, at any rate, the whole front
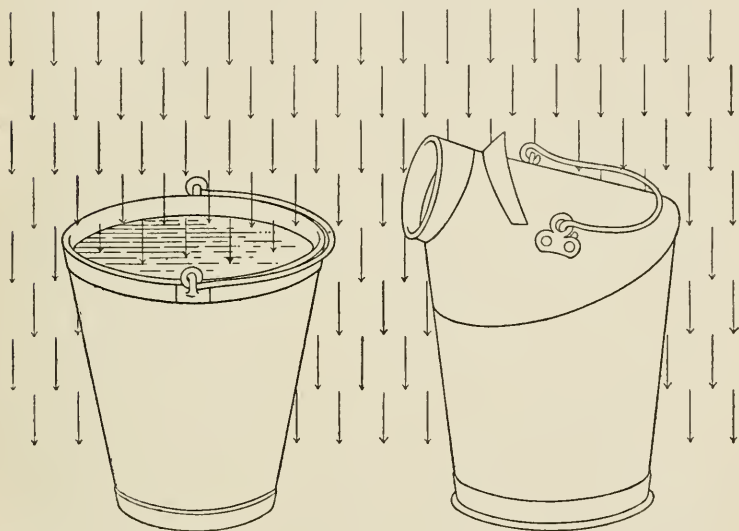
Fig. 47.—Open and protected pails.

entirely.   The milking should be done with dry hands.   A milker or worker connected with the dairy who is suffering from any disease is liable to infect the milk.   Infection may be conveyed to the milk by a tuberculous person coughing near the pail, or from one whose hands and clothes are soiled with sputum.   Epidemics of scarlet fever, diphtheria, and enteric fever have been traced to the milk supply, and back to a worker or dweller on the farm who has infected the milk in some way not always very obvious, but none the less certain.

Yet another source of contamination is the pail.   If this

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has angles inside at the joints, and if it is not treated with steam or boiled between each usage, the pail will nearly always retain a considerable number of bacteria. Unless the pails are treated in this way, the retained bacteria will contaminate the fresh milk run into them.

The following figures, taken from an experiment at Birmingham, illustrate the degree of contamination avoided by using a protected form of pail:

NUMBER OF GERMS IN 1 CUBIC CENTIMETRE OF MILK SAMPLES TAKEN BY ORDINARY MILKING METHODS, AND BY SPECIAL MILKING METHODS

		Ordinary method (open pail).	Average.	Special method (protected pail).	Average.
After 2 hours	Farm A	6,790		150	
	,, B	10,600		400	
	,, C	147,500	41,312	140	234
	,, D	360		247	
After 24 hours	Farm A	9,200		160	
	,, B	5,800,000		18,000	
	,, C	852,000	1,803,800	400	4,975
	,, D	554,000		1,340	
After 48 hours	Farm A	32,000,000		460,000	
	,, B	39,840,000		6,827,500	
	,, C	16,180,000	28,790,000	38,000	1,968,375
	,, D	27,140,000		548,000	

The Birmingham figures quoted above show the bacterial counts in milk two hours after milking, using the two kinds of pail. These may be taken as not being appreciably higher than the numbers immediately after milking, since it is well known that the bacterial content frequently undergoes an apparent reduction during the first few hours after milking and in any case the rate of increase during the first few hours is slow. Orr [1] took the bacterial content of a large number of samples of milk after milking and found the figures to vary between 17,000 and 60,000. The winter figures were higher than the summer, owing to the cowsheds being dirtier and the air, therefore, more laden with bacteria. These figures are of interest when comparing those given below with milking carried out by the milking machine.

In order to avoid the contamination arising during milking,

[1] Report on an Investigation as to the Contamination of Milk, 1908.

and also to save labour, milking machines have been introduced. These machines are devised with four cups with rubber linings which fit on to the teats. The cups are connected by flexible tubing to a closed receptacle and the whole is connected with some form of engine. The engine produces a reduction in the pressure inside the apparatus, and thus draws the milk out of the udder, a further device being introduced to make the suction intermittent. At first it was found that the suction did not really empty the udder and the cows dried off too quickly. Now, however, they can be regarded as satisfactory from this aspect, and the use of the milking machine appears to be gaining ground. From the point of view of cleanliness, however, it is very doubtful whether any improvement is effected. The machine requires the utmost care in cleaning it. The flexible tubes contain some rubber material, and cannot therefore be boiled. There are joints and corners, all of which should be kept in a state of rigid cleanliness : this requires time. Orr,[1] who carried out very elaborate investigations on both ordinary methods and on milking machines, found that the milking machines as a whole gave very unsatisfactory results. He says : " The results which might be expected to follow the use of milking machines are prevention of contamination from the udder, the air, and the milker, and the production of a milk containing a few bacteria. Experiments performed during the course of this investigation, however, prove that milk so obtained contains a large number of bacteria. Two of the best modern milking machines were under observation, and on two occasions samples drawn from each machine were examined. The following are the results obtained :

				Agar at 37° C.	Agar at 20° C.
				Per cent.	Per cent.
Machine : A	1	.	.	.	133,000	172,500
,, ,,	2	.	.	.	208,000	494,000
Machine : B	1	.	.	.	1,000,000	1,392,000
,, ,,	2	.	.	.	842,000	986,000

[1] Loc. cit.

"These results place the samples . . . amongst the worst specimens of milk. B 1 is worse than any other sample of milk examined, and B 2 is not much below the worst. The bacterial contents of A 1 and B 2 are only exceeded by one sample.

"These results show the machine to be a source of great contamination. The reasons for pollution are mainly, first, the difficulty of cleaning, and, secondly, the sucking in of air and dust when the cups fall off. The difficulty in cleaning is due to the amount of tubing, which in one machine reaches a length of several yards and in the other of several feet. The machine is cleaned by running first strong soda-water through all the tubing and apparatus, and then washing thoroughly with tepid water. Hot water, of course, cannot be used, and certainly not steam, both being liable to destroy the rubber. The tepid water is incapable of killing the organisms in the tubes, and the apparatus stands from after the morning milking till the evening milking, during which time organisms in the water in the tubes are multiplying and are ready to contaminate the new milk passing through. When the cups fall off the teats, the bacteria-laden air is sucked into the tubes and contaminates the milk. There is no means of preventing the cups from falling on to the cowshed floor, as they sometimes do, and, the suction being continuous, manurial dirt, which is very rich in bacteria, is drawn into the apparatus."

"The machines observed have been given the best chance possible, as the owners are expert farmers, and the cleaning is carried out in the dairy by experienced dairymaids. In both cases the cans were thoroughly cleansed, the cows groomed, and the cowsheds excellent, so that the milking machine alone can be blamed for the very high bacterial content of the milk.

"Such disappointing results might be avoided if tubing could be used through which steam might be passed, and if the cups had check-valves to prevent the sucking in of air and dust at the moment the cups fall off the teats."

In the recent inquiry made by the Committee on the

Production and Distribution of Milk,[1] answers were obtained as to the frequency of cleaning of the machine. It is clear that, if the machine is to be cleaned properly, it requires a person of considerable intelligence, on account of its complexity, and it will take a long time to do. From the replies it would appear that from two to three hours are required for a thorough cleansing. Each machine is used for a number of cows at each milking. The Committee say : " The usual method of cleaning resorted to consisted of passing, by suction, first cold water and then hot water through the teat-cups and milk-conveying tubes into the milk-receiver. In some instances the hot water contained a disinfecting agent, in others the teat-cups were regularly brushed out ; but it was obvious, from the general tenor of the replies, that the cleaning was, as a rule, not sufficiently thorough or systematic. The time given to the daily cleaning appeared to be about 5 minutes per receiver and associated parts, and it was added that the rubber parts required more perfect cleaning periodically. In most cases the machine was taken to pieces and thoroughly cleaned weekly, fortnightly, or monthly. Again, it was obvious that on many farms there was no definite procedure laid down for the dismantling and careful examination of the working parts and the parts which come into contact with the milk. At no stage in the management of a mechanical milker is there greater need for attention to detail than in the daily cleansing. The other work of a cowman is by no means of a cleanly nature, and it is not to be expected that the average cowman will carry out his work satisfactorily unless the necessity for thorough cleansing of the milking machine is understood or regular supervision is given by the farmer or bailiff."

The milking machine, as commonly used, is of the nature of a glorified long-tubed bottle, which has justly been condemned as a positive and dangerous source of contamination. The chief difference is that, in the one case, the contamination is at the source, and in the other it is at the end and must pass

[1] Final Report of the Committee on the Production and Distribution of Milk, 483, 1919, pp. 54–66.

inevitably into the baby's mouth. Rubber tubes, or tubes containing rubber, are very difficult to keep clean, as they cannot be boiled, and must be avoided where cleanliness is essential.

After milking, the common practice is to filter the milk through some kind of filter. The Ulax, of which a figure is given in fig. 48, is a common type used. If the milk is drawn with strict attention to cleanliness, then filtering is unnecessary. If, however, dirty methods are permitted, filtering will in most cases make the position no better. With dirty cows and dirty methods, there will almost certainly be a good deal of gross contamination. The particles, or even pieces, which fall into the pail contain large numbers of bacteria. The process of filtering breaks up the dirt and disseminates the bacteria. True, it holds back much of the visible dirt, but this makes a false sense of security. Thus, Savage found the following figures :

	Number of organisms in unfiltered sample.	Amount of sediment per 100 c.c.	Number of organisms in filtered sample.	Amount of sediment per 100 c.c.
Experiment 1 .	242,000	0·022	230,000	0·022
,,　　　2 .	408,000	0·06	139,000	0·025
,,　　　3 .	600,000	0·048	760,000	0·03

The milk, after being drawn, has a temperature not much below that of the cow, and it should be at once cooled. If it is not cooled the temperature of the milk remains high for some time, as milk is a fluid in which the heat is transmitted or lost very slowly. The bacteria present will find the temperature suitable to their growth, and will multiply more rapidly than if the milk is cooled at once. For cooling the milk, an apparatus is used in which the milk is passed in a thin film over tubes filled with cold or iced water, according to the temperature of the weather. The milk, after cooling, should flow direct into sterilized bottles, or churns, which should not be opened before delivery to the customer
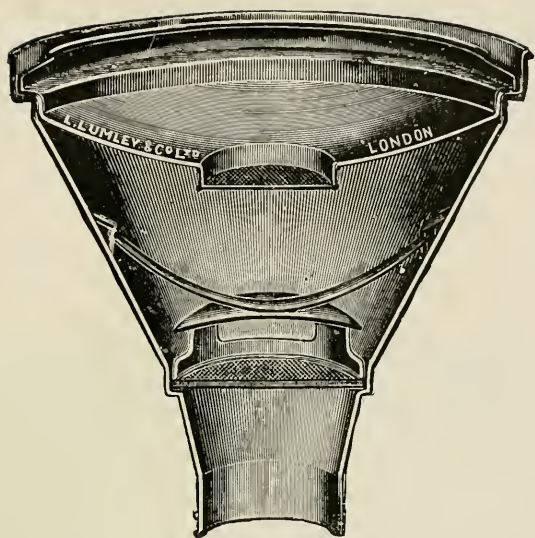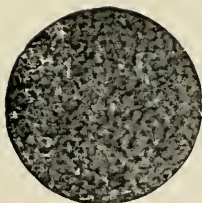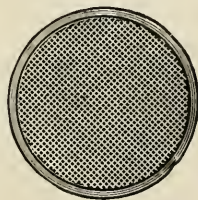
Fig. 48.—A Ulax filter. A shows the section of the filter ready for use. B is the cap held in position by the spring, which is caught at either end under a piece of metal. C is one of two wire gauze disks which hold D, a soft disk, between them, both C and D being held by B.

(see fig. 49). Unfortunately, however, this desirable procedure is too seldom followed. The milk is by no means always cooled. Even if a cooler is used, it is not always properly cleaned, and is sometimes kept in a dirty shed or barn, or used out-of-doors. The milk may then receive further bacteria in the process, both from the dirty cooler and from the air of the shed. The milk is commonly poured into large churns which may be, but will often not have been, sterilized. The bacterial content of churns
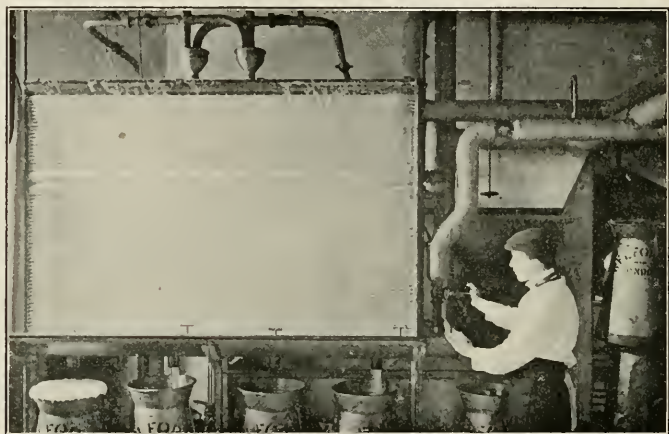
FIG. 49.—Showing milk passing in a thin film over the cooler and thence into churns below. If desired it can also pass directly into bottles. In this latter case a special apparatus stops the flow when the amount the bottle is to hold has entered.

which have been nominally cleaned, or have even been cleaned reasonably carefully, has been investigated, and it has been shown that ordinary cleansing still leaves a large number of bacteria behind. Thus Orr [1] states: " Four cans, which had been scalded by the farmer and which were ready to receive the milk, were each washed out with 100 c.c. of distilled water, and the number of organisms per c.c. of this water was, in one 48,000, in another 2,325,000, in a third 19,960,000, and in a fourth 605,000. Specimen 1,

[1] Loc. cit.

which shows the best results, was obtained from a can in a town cowshed where the cans were filled with actually boiling water containing soda, and allowed to steep for half an hour. Specimens 2, 3, and 4 were cans simply filled with so-called boiling water.''

Recent work by Cumming and Mattick [1] gave the following figures :

CLASSIFICATION OF CHURNS FOR INSPECTION—OCTOBER 9TH
TO NOVEMBER 20TH, 1919.

| | Clean and sweet. | | Milk absent, evil smell. | | Churn not washed, milk present. | Churn badly washed. |
	Dry.	Wet.	Dry.	Wet.		
Number :	81	140	5	118	81	75
Per cent.:	16	28	1	24	16	15
	A	B	C	D	E	F

Total 500.

Several of the results obtained from E were too numerous to be counted. F gave counts as high as 18,400,000 and 5,300,000. The others varied from 170 to 6,200,000. If the churn containing 18,400,000 had 17 gallons of milk put into it, there would be about 240 per c.c. in the milk, derived from the churn alone.

Further contamination takes place in transit, if churns with ventilation-holes in the lid are used, or if the cans are opened on the journey, or, as is also done, the milk is poured at the station from one churn into another. In the shop, again, it has further opportunities for contamination. The counter-pan is probably far from sterile, and is often left open or partly exposed to the air. The passage in and out of customers to the shop, and the wind outside, will inevitably send some bacteria into the milk. If taken on the round, the milk on a hot day will gradually get warmed up and the bacteria will multiply ; the milk is often run through a tap, which is hardly likely to have been effectively cleansed, and the dust of the roads is blown

[1] " Inquiry Concerning the State of Cleanliness of Empty Milk-churns '' (*Journal of Hygiene*, 1920, vol. xix, p. 84).

into the milk as it leaves the tap. The customer's jug will again probably add to the contamination, and the bad practice of leaving milk exposed in the home adds a further quota of bacteria to the already heavily laden fluid.

It is evident that the methods of milk supply and delivery in this country still leave much to be desired. The heaviest and most dangerous sources of contamination are at the farm, and much could be done, without appreciable increase in expenditure, to improve the general cleanliness of the milk. The cows and the milking-sheds can be kept clean, and the milker can wash his hands, while the outlay on protected pails is not much greater than that required for open pails. These items alone would be a great improvement, and require only some education and intelligence. Other requirements involve some additional expenditure. For example, the milking-sheds should be specially constructed, and the cows should preferably not live in the place in which they are to be milked. These points are, however, beyond the scope of this present work, and cannot be dwelt upon.

Bottling on the farm is expensive, and a higher charge must be made for the milk. The bottles are liable to get broken in transit, and the charges made by the railway companies for carrying bottles are very much higher than those made for carrying milk in churns. It is hoped that enough has been said to give some idea as to the nature and sources of the contamination of milk.

SOMETHING has already been said as to the number of bacteria which are found in milk. The sources from whence they enter the milk have also been considered in outline. It is still necessary to consider the nature of the bacteria commonly found, their multiplication, and their effect on the milk.

The pathogenic bacteria, when present, are usually found in numbers which are relatively insignificant as compared with the total number present. From the point of view of health the small numbers are of great importance, whereas in a general bacterial count they are almost negligible. They are usually derived either from the cow or from the milkers, although it is evidently possible that they might sometimes enter attached to particles of dust which had been contaminated. The vast majority of the bacteria in milk are non-pathogenic, at any rate in small numbers. It seems fairly evident, however, that gastric and intestinal disturbances can be produced in infants by the ingestion of large numbers of living non-pathogenic bacteria (cp. Park and Holt, p. 257). These bacteria in milk are derived from the air of the sheds or from dust, etc., blowing into the milk. Their variety is great, and includes spores, moulds of various kinds, sarcinæ, cocci, and bacilli. Of these last there are many strains and varieties which are capable of splitting lactose with the production of lactic acid, and the commonest of these is known as *Bacillus acidi lactici*. The equation representing the change is :

$$C_{12}H_{22}O_{11} + H_2O = 4C_3H_6O_3(CH_3 \cdot CHOH \cdot COOH.)$$

Lactose.   Lactic acid.
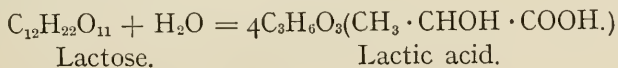
Some of these bacteria have other actions on the milk which are of less importance hygienically than the production of lactic acid. The presence of this last substance is detrimental to the milk, both because the food-value of the milk is reduced by the splitting of the lactose, and also because the acid tends to coagulate the protein in the milk and to render it less digestible. Lactic acid, as such, has been stated to have a beneficial effect on the health of adults by improving the condition of the alimentary canal. This in itself is somewhat doubtful, and in any case is not here under consideration. The organism commonly associated with mastitis, and responsible for numerous epidemics of sore throat, is believed to be the *Streptococcus lacticus*, of which there are probably a considerable number of varieties widely distributed over the world.

It has already been shown that the milk when first drawn ordinarily contains many fewer bacteria than on its delivery to the consumer. This is only in part due to additional contamination, but is mainly owing to the multiplication in the milk of those which gained access in the early stages. Under favourable conditions bacteria multiply rapidly. It is not practically possible for commercial purposes to obtain milk which is free from bacteria, so that it is necessary to render the conditions as unfavourable as possible for their multiplication. The most important condition is temperature. The majority of the bacteria in milk, especially those forming lactic acid, grow rapidly at a temperature approximating to that of the human body and higher. Thus Slater [1] found at 45° C., the conditions as regards medium of growth being favourable, that the generation time of the lactic acid bacillus was 21·5 minutes. For *B. coli* at 42° C. approximately the same time of generation was found by Lane-Claypon.[2] At lower temperatures the rate of growth is reduced, and at 20° C. it may be about three times as slow as at 42° C. for *B. coli*, while Slater obtained no growth from the lactic acid bacillus

[1] *Trans. Chem. Soc.*, 1916, vol. cix, p. 2.
[2] *Journ. of Hygiene*, vol. ix, p. 239.

at 20° C. At higher temperatures than the optimum the rate of growth is reduced, and falls with great rapidity until the death point is reached. Some are more resistant to heat than others, and survive even 100° C. for a short time ; but they do not multiply, and, on the reduction of the temperature, take a little time to recover from the effects of being heated. Milk when freshly drawn contains substances which have been filtered out from the blood, which agglutinate bacteria, holding them together in clumps and preventing them from moving freely in the milk. These bodies are known as agglutinins. Their action in clumping bacteria has given the impression that milk contained substances which definitely destroyed bacteria.[1] Bacterial counts made on plates in the usual way showed a decrease in the bacteria present, within the first few hours after milking. Numerous investigators have worked on this subject and obtained analogous results. The most interesting results for the present purpose are those of Rosenau and McCoy,[2] who added a drop of a culture of *B. typhosus* to the milk, and, while demonstrating the reduction, showed that if the clump of bacteria were broken up the reduction was only apparent and not real. The effect is destroyed by heating, but is restored by adding a drop of typhoid serum which has agglutinating power. This is shown in the table on page 254.

The power of agglutination soon passes off, and 4–6 hours after the milk has been drawn its effects are no longer found. If the milk be heated the agglutination effect is abolished, and on the other hand is prolonged if the milk is kept cool. Thus, Myer Coplans[3] found that at blood-heat the inhibition lasted one hour only, but persisted for twenty-four hours if the milk was kept at 0° C.

For all practical purposes nothing is gained by the

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[1] When bacteria are plated with the object of counting their numbers each clump will count only as one bacterium, since it shows as one colony only.

[2] "The Germicidal Properties of Milk" (*Journ. Med. Res.*, 1908, vol. xviii, p. 165).

[3] "On some Vital Properties of Milk" (*Lancet*, 1907, vol. ii, p. 1074).

	Bacteria per loopful.					
	At once.	2½ hours.	4½ hours.	6½ hours.	8½ hours.	
					Moderate shaking.	Mixed with pipette.
B. *typhosus :* raw milk	1,880	1,380	1,060	1,480	1,980	12,200
,, ,, boiled milk	2,120	4,020	*a. b.* 800,000	*a.*	*a.*	*a.*
,, ,, one drop, typhoid serum added	2,100	2,040	1,920	2,300	1,260	*a. b.* 20,000
,, *typhosus :* boiled	2,280	2,360	7,020	6,480	10,860	*a. b.* 60,000
,, *typhosus* in broth, serum added	1,830	970	2,920	9,180	11,160	*a. b.* 100,000
Organisms in milk alone	0	1	2	2	2	46

a = innumerable.   *b* = about.

presence of agglutinins, because milk, as delivered to the customer, is usually from 12 to 15 hours old, or even more, so that any inhibitory effect will have worn off. Organisms implanted into milk grow more readily in milk which has been heated than in raw milk. Here also, however, by the time the milk has been delivered there is no very great difference. At the same time the point may profitably be borne in mind in connection with the question of commercial pasteurisation which is considered in Chapter XXII.

Milk undoubtedly forms a favourable medium for the growth of a large number of bacteria ; a good deal depends on the individual peculiarities of the organism, some having a more vigorous growth than others. In milk it has been shown that the growth of the lactic acid bacillus, and the consequent development of acidity due to the splitting of the lactose, inhibits the growth of certain organisms, which, even though they may multiply freely during the early hours after milking, are gradually killed off by the acidity of the medium. Since different samples of milk show different contents of bacteria, and those contents are made up of different proportions of the various strains, no figures can be given for the general rate of growth. Further, the temperature will have an important bearing on the multi-

plication of bacteria, as already shown. The following table, taken from the work of Conn and Stocking [1] shows the gradual increase in the acid-forming bacteria of various kinds over the others.

Time after milking.	Total bacteria per c.c.	Acid-forming per c.c.	Liquefying per c.c.	Per cent. of acid-forming.
Fresh . .	12,550	1,250	200	10
Three hours .	12,250	2,000	200	16
Six hours. .	19,650	2,250	800	23
Nine hours .	56,900	20,250	550	36
Twelve hours .	114,250	68,400 (Practically all Bacillus Acidi Lactici)	1,900	60

This appears to be the common result of the fight between the bacteria if they are left long enough. Of the acid-forming varieties the lactic acid bacillus usually gains the victory. An average sample of milk which has turned " sour " will contain a large number of bacteria, of which some will be dying or dead, and the majority will be lactic-acid forming bacteria. The milk may have a disagreeable smell and taste, apart from the question of acidity, owing to the products arising from the action of the other varieties. Milk which does not appear " sour " when raw will sometimes, especially in hot weather, " curdle " on heating, when it might have taken some hours to curdle if it had not been heated. This is due to the action of the heat combined with the acidity, which results in a coagulation of the protein of the milk. A higher degree of acidity is necessary for coagulation in the absence of a high temperature—that is, there must be more lactic acid. The caseinogen of milk does not coagulate on being heated without acid. Evidently the " souring " of milk is due to the multiplication of the lactic acid bacteria, and it is easy to see how the temperature at which the milk is kept will make a great difference in the keeping of the milk. Milk which is not cooled after milking,

[1] " Studies on the So-called Germicidal Action of Milk " (*Rev. Gén. du Lait.*, 1902–3, vol. ii, pp. 2, 5, and 298).

or which is left exposed to the sun, or placed near the fire or in a hot room, will have a great rise in its bacterial content as compared with a similar sample of milk which is placed in a cool spot or where devices for keeping it cool are used. The great value of keeping milk cool in transit will be appreciated, and it is regrettable that cooled vans for the transport of milk are not available in this country.

The milk which a few years ago was sold as " sour milk " was heated and then inoculated with a special lactic acid bacillus. By this method a nicer milk is produced, as the products of the other strains, which are sometimes disagreeable, are eliminated, and only the pure effect of the lactic acid bacillus obtained. A good deal has been written on the value of lactic acid for infants. It is difficult to understand the reasons for such views, and they are not founded on any scientific investigations. The " Eiweissmilch " of Finkelstein, used by him in cases of summer diarrhœa, and other infections, is fermented, not in order to obtain lactic acid, but to reduce the amount of lactose in the final mixture.

Some writers have argued that the bacteria in milk are beneficial to infants, and they even suggest that the tubercle bacillus may produce an immunity to the disease. There is no basis whatever for these statements. In fact, other attempts to protect against disease by the ingestion of antitoxins or other protective substances have been signalized by failure, unless the walls of the alimentary canal are in an unhealthy condition. The protective substances are attached to protein molecules which are broken down in the process of digestion, and the protective action is destroyed. If immunity is to be acquired by milk it must be by the penetration of the bacteria from the alimentary canal into the tissues round it and there setting up a reaction. It is usually inadvisable to attempt inoculation with an unknown dose of living organisms ; better, if considered advisable, is a known dose of dead organisms, as is the case when inoculation is practised in medicine. Further, in view of the very few bacteria in milk as obtained

by the infant from the breast, it is difficult to see why the addition of bacteria to the food of the artificially fed child should be an advantage. On the other hand, there is much evidence showing the detrimental effect of a high bacterial content in the milk of infants. A comprehensive investigation was carried out by Park and Holt [1] in New York City, the results of which were published in 1903. They found that the children who received milk with a very high bacterial content showed the worst results " not only by the death-rate, but by the amount and the severity of the diarrhœal diseases, and the general appearance of the children as noted by the physicians." These observers attribute some of these effects to the accumulation of toxic bacterial products.

There can be no doubt that milk should contain as few bacteria as reasonably possible, and standards have been laid down in order to secure a satisfactorily low bacterial content. Some account of these standards must now be given.

The first introduction of standardized milk was made in America. Physicians specially interested in children found that the milk supplied in the ordinary way was of very unsatisfactory quality and in urgent need of improvement. They formed a body known as a Medical Milk Commission, and persuaded certain advanced dairymen to carry out reforms in milk production. These reforms included testing for tubercle, together with cleanliness of the cows, of the milkers, the pails, and of care in each stage of handling the milk, as has already been described in the previous chapter. As a result of experience, it was found that by adopting these methods the bacterial content of milk could be enormously reduced.

The Medical Milk Commissions spread rapidly, and the majority of the large towns in the United States of America have these commissions at work. They are purely voluntary

[1] Park and Holt. " Report upon the Results with Different Kinds of Pure and Impure Milk in Infant Feeding in Tenement Houses and Institutions in New York City " (*Arch. of Ped.*, Dec. 1903).

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agencies which issue certificates to the farms whose methods
and standards reach the requirements laid down by the
Commissions. The milk is sold at a somewhat increased
charge, and the farms pay for their inspection and super-
vision, the whole being self-supporting. The standards
laid down by the various commissions are very similar. The
number of bacteria is not to exceed 10,000 per c.c. when
delivered to the customer, and bacterial counts are made of
samples of milk from each farm, usually twice a week.
Standards are also laid down as to the fat content (varying
from 3·5 to 4·5) and for the total solids which must be present.
The farms are subject to inspection in every detail, and score-
cards are kept showing the marks obtained on inspection.
The milk is bottled on the farms, the bottles capped with
special covers, and must be delivered cooled to the customers.
Subject to the above restrictions and to satisfactory inspec-
tion and bacterial and chemical results, the milk may be sold
as "certified" by the Milk Commission. It is intended
especially for infants and invalids. The bacterial count
affords an astonishingly accurate test of the methods
employed. It is impossible to reach a standard of 10,000
per c.c. unless the greatest possible care is taken at each
stage of production, even a small slip being likely to raise
the number present above the limit. On the other hand,
with practice and real care, the figure reached may be
very much lower, amounting only to 1,000 or 2,000, and
occasionally less. These figures cannot be reached without
special apparatus and some outlay in relation to the dairy
premises and to facilities for sterilizing the pails and bottles,
and for cooling on transit in summer. It can practically
not be obtained except by bottling on the farm. Evidently
therefore the producer is entitled to make a higher charge
for this milk.

It is certain, however, that an immense reduction in
bacteria can be effected by attention to the most ordinary
requirements of cleanliness, of cattle, of milkers, and of
utensils. Even with some unnecessarily careless methods
the count can be reduced to a few hundred thousands per

c.c. instead of the many millions frequently found. It has already been pointed out that the bacteria destroy the food-value of the milk by breaking down the lactose, and some varieties will break down protein ; also the souring of milk renders it unfit for sale.

In order to stop the ravages of the bacteria, milk may be pasteurised,[1] which, if properly carried out, reduces the bacterial content. Numerous American cities have laid down regulations for the milk sold within their boundaries, giving the maximum which may be found in both raw and pasteurised milk. The milks are " graded " according to the number of bacteria found, and it must be stated whether it has been previously pasteurised or not.[2] Pasteurised milk is held in America to be unfit for infants, and, if it is to be

[1] The principles and processes are described in Chapter XXII.

[2] The State of New York issued regulations which came into force in November 1914, and which described explicitly the nature of the grades in milk. Briefly, they amount to the following :

Grade A, Raw.—This milk must not at any time previous to the delivery to the consumer contain more than 60,000 bacteria per c.c., and such cream not more than 300,000 bacteria per c.c. It must be delivered within thirty-six hours from the time of milking, unless a shorter time shall be prescribed by the local authorities. It must be delivered to the customers only in containers sealed at the dairy, and must show its grade and the name and address of the dealer.

Grade A, Pasteurised.—Such cream or milk, *before pasteurisation*, must not contain more than 200,000 bacteria per c.c. After pasteurisation, and previous to the delivery to the consumer, it must not contain more than 30,000 per c.c. in the milk and 150,000 per c.c. in the cream. It must be delivered in sealed containers and labelled " Grade A, Pasteurised."

Grade B, Raw.—Such milk must not at any time previous to delivery to the consumer contain more than 200,000 bacteria per c.c., and such cream not more than 750,000 bacteria per c.c.

Regulations as to delivery as for Grade A.

Grade B, Pasteurised.—Such cream or milk, before pasteurisation, must not contain more than 300,000 bacteria per c.c. After pasteurisation such milk must not contain more than 100,000 bacteria per c.c., and such cream not more than 500,000 per c.c. The milk must be delivered within thirty-six hours after pasteurisation, and such cream within forty-eight hours after pasteurisation. It must be labelled " Grade B."

Grade C, Raw and Pasteurised.—This grade has no prescribed bacterial standard, but must be delivered within forty-eight hours from the time of milking in the case of the raw milk, or within forty-eight hours after pasteurisation.

The cows from which the milk of Grade A is obtained must have been

heated again in the home, it should certainly not be used for this purpose. The grading of milk involves a good deal of machinery, seeing that it includes bacterial counts, inspection, and so forth. It should be noted that the graded milk is of a lower standard than that " certified " by the Medical Milk Commission.

In this country the only legal standard has been in regard to the fat content, which has been fixed at 3 per cent. In addition, milk must not be adulterated or diluted in any way.

It should be noted that the cream is richer in bacteria than the milk below it. The fat globules of cream in some way catch the bacteria and carry them up to the surface in " rising."

No bacterial standard is required in this country for the general milk supply. Some interesting figures of a bacterial content of milks from high-class dairies were obtained by certain investigators,[1] and it was shown that many of the samples taken had a bacterial count of several millions per c.c. The milks were supplied to seven child-welfare centres, and twenty-seven samples were examined.

In 1920 the Ministry of Health, in co-operation with the Ministry of Food, decided to grant licences to standard farms for the production of two special classes of milk—Grade A

tested at least once in the previous year with tuberculin, and any tuberculous cow must be excluded from the herd.

For Grade B the cows must be healthy, as disclosed by an annual physical examination.

The farms producing all these classes of milk are subjected to inspection, and are themselves graded by a system of score-cards. By this method marks are allowed for the various items concerned in the production of milk, and farms supplying Grade A milk must reach a higher percentage of milk than those supplying milk of Grade B, and these, again, a higher percentage than those supplying milk of Grade C.

The regulations issued by the Department of Health for the city of New York define milk of Grade A as being suitable for infants and children, Grade B suitable for adults, and Grade C for cooking and manufacturing purposes only.

The regulations of New York City for the farms and dairies connected with the milk supply are extremely detailed.

[1] *Publications of the National Clean Milk Society.*

and Grade A (certified). The farms are inspected both before the certificate is granted and at intervals during the period of production of the special milk. Score-cards have been prepared for the purpose of allotting marks for the condition of the cows as regards disease, for the equipment of the farm, and for the methods used in production of milk. Certain minimum totals must be obtained. The cows must be tested with tuberculin so as to ensure that they are free from tuberculosis within the limits of certainty secured by the test. Grade A (certified) must be bottled on the farm and the bottles closed with appropriate fixed caps, which cannot be removed without such removal being shown. The cap must bear the name and address of the producer, or of the farm where it is produced, the day of production, and the words " Grade A (certified) milk." The milk, on delivery to the consumer, must not contain more than 30,000 bacteria per c.c., nor *B. coli* in one-tenth c.c. Grade A milk can be despatched in sealed churns from the farm and can be bottled at the town dairy, subject to the equipment and methods employed there being considered satisfactory by the inspector sent by the Ministry.

Both these milks will be of a higher standard of purity than the average supply, and command a higher price. They are specially suitable for infants and invalids, the additional cost at present prices making them almost prohibitive for ordinary purposes.

If bacterial counts of milk obtained from retailers at random are made, it will probably be found that here and there samples will be well below the figures mentioned above for the ordinary milk supply. This would almost certainly be due to the fact that the milk had been heated (pasteurised) in order to preserve it, and the greater number of bacteria thereby killed, so that they no longer grow when the sample is plated out. The pasteurisation of the milk supply is considered in the next chapter.

CHAPTER XXII

THE practical impossibility of producing milk free from bacteria has been explained in the preceding chapters. It has also been shown that it is impossible to be certain that any given sample of milk is free from pathogenic germs. These last, while numerically small, even when present, are more to be feared than the other very numerous varieties, which, however, render the milk unpleasant to take when they have reached great numbers.

Milk has often to be carried long distances, and is usually not delivered to the customer before some eighteen or more hours have elapsed after milking. The prime cause of difficulty lies in the bacteria which are present ; and the position is best met by heating the milk and thereby killing the germs.

The problem is not, however, met by merely making this statement, for many questions arise in connection with it. Among the most important ones are the following :

(1) Can milk be heated without detriment ?

(2) If so, to what temperature can it, or should it, be heated ?

(3) What methods are best to employ ?

(4) At what stage of its transit from cow to consumer should the heating be carried out ?

These various questions cannot be considered entirely independently, since they overlap on certain important items. Moreover, certain matters have not been investigated as fully as might be desired, and there are differences of opinion among the experts on the various branches. More serious, however, is the divergence of views which

has arisen from the loose terminology which has been employed in talking about milk which has been heated. The term " heated " is here used deliberately, since it is wide in its application, and covers all the methods and temperatures which are employed. In the literature terms such as " boiled " or " sterilized " are used, often without any careful explanation of the precise method employed, and too frequently the same term will be found to have been used by different authors to imply different processes.

The processes commonly used in heating milk can be included under one or other of the terms " pasteurised," " boiled," or " sterilized." At the same time further statements are needed as to the length of time of heating, and, except in the case of boiled milk, the temperature reached should also be stated.

" Pasteurised " milk means that the milk is heated gradually up to a temperature which is below boiling point ; that when the given temperature is reached the milk is then cooled quickly. This is only a general statement, and in practice the milk may be maintained for some minutes at the highest temperature used ; secondly, the temperature used varies considerably ; thirdly, the degree of cooling used is not necessarily the same. It will be seen, therefore, that the term " pasteurised " requires some qualification. The processes employed are described more fully below.

" Boiled " milk has been used to describe any process where the milk is made to reach the temperature of the boiling point of water, namely, 100° C. or 212° F. The boiling point of milk is slightly higher than that of water, but this is not taken into consideration. The term is sometimes used when the process in question is really pasteurisation ; on the other hand, the milk is often spoken of as sterilized when the process is merely boiling. Again, the length of time over which the temperature is maintained is often not stated, whereas this is a point of great importance.

" Sterilized " milk should be milk which has been treated so as to destroy the bacteria present, rendering it sterile. If heat be employed for this purpose the temperature used

must be well above boiling point and must be prolonged, in order to destroy the spores which are almost certainly present. Yet the word is often used to denote boiling. It is the inaccuracy of statement which has led to much of the difference of opinion in regard to the heating of milk.

It is necessary to consider the general changes which take place on heating milk and at what temperature these commence. The majority of the pathogenic bacteria are killed at a temperature well below 100° C., although some of the nonpathogenic ones will survive this temperature for a time. For all ordinary purposes, however, the temperature reached in pasteurisation is sufficient to render the milk bacteriologically harmless. Since the whole object of heating is to destroy the greater number of the bacteria, there is clearly no object whatever in employing a higher temperature. At the present time, for practical purposes, pasteurisation is undoubtedly the process which should be used.

Slight chemical changes take place on pasteurisation. The ferments which are of no biological importance are destroyed ; the protein is rendered slightly more digestible. There is some degree of precipitation of calcium citrate, and it is possible that a part of the lact-albumin is coagulated and deposited. The evidence is not very convincing on this last point, and in general the changes may be regarded as of little or no importance. There is no evidence to show that any one of the accessory food factors is affected adversely by pasteurisation.

When milk is heated to boiling point there is some slight further destruction of bacteria, and the protein appears to be rendered rather more digestible. If the temperature of 100° C. is only just reached there would seem to be very little distinction between this method and pasteurisation. If, however, the heating be prolonged, important chemical changes take place. The sugar tends to caramelise and a brownish tinge appears in the milk. The flavour alters, and this change is much disliked by many. The lact-albumin is affected, and will coagulate ; if the heat be maintained for so long a period as one hour it has been shown that the

anti-scorbutic factor is damaged or destroyed. From the
practical point of view, with which this book is concerned,
such a procedure is entirely without purpose. It is detri-
mental and expensive, in addition to being a process almost
impossible to carry out in the home. Milk, when boiled
over the flame, froths up and over the pan, and is partly
wasted and makes much mess for the housewife. The
machinery required on a large scale for heating milk to a
temperature above pasteurisation is elaborate, and as a
whole available only in laboratories. The same remarks apply
generally to any process of " sterilization " of milk as a fluid.
In practice, both on a large scale and in the home, the
process to be employed is essentially that of pasteurisation.
It is this process alone which will be described here.

The answer to the first question is, then, that milk can
be heated without detriment when the process employed
is pasteurisation. It is now necessary to consider the
temperatures concerned in pasteurisation. These vary in
different processes. When employed for commercial pur-
poses the temperature is kept as low as is consistent with
the destruction of the bacteria, in order to avoid the
use of more fuel than is absolutely necessary, since this
would add to the cost. The temperatures used in the
process vary from 140° F. (60° C.), to 170° F. (76·7° C.)
according to the practice of the firm individually concerned.
Many investigations have been carried out to ascertain the
temperatures at which the pathogenic germs likely to be
present are destroyed. The results obtained vary. It may
be assumed, however, by comparing the figures given, that
a momentary heating up to 170° F. will suffice, or a lower
temperature lasting over a more prolonged period : 140° F.
is on the low side for safety, since evidently in any apparatus
used there will be an early period when the temperature is
rising, the effect of which will be added to that produced by
the highest temperature, so that milk which has just been
brought momentarily to a temperature of, for example,160°F.,
will have been exposed over a longer period to a temperature
sufficiently high to destroy the harmful bacteria.

Numerous workers have studied the thermal death-point of the tubercle bacillus, under varying conditions and with different results. Taking the general results, it seems that it is wiser to employ a temperature over 140° F., and 160° F. is probably desirable for safety.[1]

There are two main processes used in pasteurisation on a large scale : the " holder " and the " flash." In the former the milk is heated to the temperature decided upon, and is held at that temperature for a short period, usually about two minutes, before cooling. In the latter process the temperature to be reached is just touched and the milk promptly cooled. As a whole, the flash process requires less fuel and is more widely used than the holder process.

It is stated that the cream-line is injured if the milk is heated to above 150° F., and for this reason many people are reluctant to use a higher temperature.

When pasteurisation is undertaken in the home the temperature is generally allowed to rise considerably above that employed commercially, and, while not reaching the boiling point, often reaches between 180° and 200° F., or 80° to 90° C. No detriment is done to the milk by such a temperature, and it is undoubtedly safer.

The methods of pasteurisation now require to be dealt with. Those employed commercially differ from those employed in the home, and will be considered first. The object in commercial pasteurisation is to secure an even heating of all parts of the milk without loss of available heat. This is more readily achieved by means of coils in or around which the milk is brought into near contact with hot water or steam. In an apparatus where the milk circulates in the coils the heat is applied outside the coils, or the milk may be outside and the hot water inside. Again, there may be two tubes, one inside the other, for milk and water respectively (cf. fig. 50). The two systems for milk and water must,

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[1] Some dairymen consider it advisable to keep the milk at a low temperature, say 145° F., for a longer period, thus increasing the effect on the bacteria without risk of injury to the cream-line.

of course, be entirely separate.   Unless the milk is arranged
in relatively thin layers, either in- or outside the tube, the
heating is apt to be irregular, and one part may be over-
heated and the other not heated enough.   If a large con-
tainer is used for the milk, then some form of revolving
paddles and of stirrer, charged inside with hot water or
steam, must be used (see figs. 50 and 51).   Frequently the
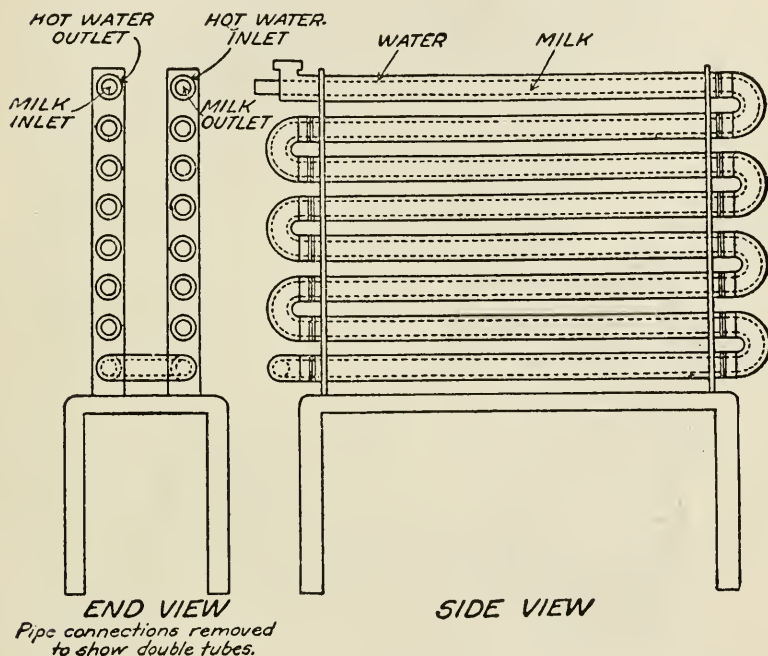
FIG. 50.—Showing double tubes in apparatus for pasteurising milk.

milk is passed through two sets of coils, and that portion
whose heating has been completed may be carried so as to
pass in a coil which is surrounded by the incoming cold
milk.   By this arrangement the outgoing milk is cooled
and the incoming warmed.   Various devices are in use for
the purpose of utilizing the heat, which must be given up by
the outgoing milk.   One such is shown in fig. 52.   After
heating the milk must be passed through some form of cooler,

in order to bring the temperature down without delay. This is of importance, since otherwise the surviving bacteria would multiply rapidly in the warm fluid. Milk is slow to heat in bulk, and also slow to cool; hence the necessity for

MILK OUTLET

THERMOMETER

STEAM AND WATER JACKET

MILK INLET

REVOLVING PADDLE

STEAM INLET

MILK CHAMBER
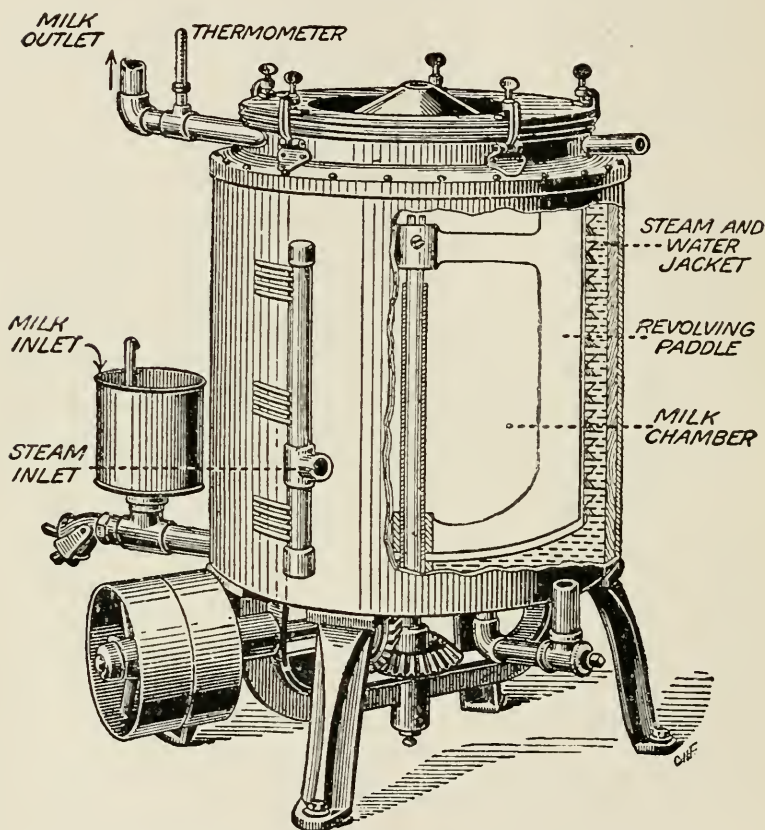
Fig. 51.—A simple pasteurising apparatus. The milk is stirred by revolving paddles.

handling it in thin layers. After cooling the milk is passed direct into bottles or churns for transit.

Certain difficulties arise, or are liable to arise, in connection with commercial pasteurisation. The arrangements for heating do not always work as smoothly and regularly

as might be wished, and variations in temperature arise, usually resulting in insufficient heating; also the apparatus is difficult to keep clean.

The first of these difficulties depends upon the apparatus itself, but even the best ones will go wrong at times, and only a few dairies can afford a relief apparatus in the event of a break- down. Then the temperatures require watching, and this should be done by someone of sufficient intelligence and training to appreci- ate the importance of accuracy. Failing such care, there may be days on which the temperature is considerably below that required, or it may rise irregularly, and beyond that in- tended.

Cleanliness is by no means easy to secure, for there must of necessity be coils

FIG. 52.—Showing a method of utilizing the heat of the pasteurised milk to warm the cold in-coming fluid and *vice versa*.

or pipes, together with bends, outlets, etc., where milk from the previous occasions will accumulate unless the whole apparatus is scrupulously cleaned after each use. Precisely the same sort of thing happens as in milking machines, and in churns (cp. p. 249), and the milk, after pasteurising, may easily be recontaminated in passing from the pasteurising

to the cooling coil. This is well shown by the figures of Pennington and McClintock [1] given below.

I

Material examined.	Count per c.c.	24 hours later. Count per c.c.
Milk from first tank	1,504,000	25,380,000
,, ,, second tank	2,250,000	37,800,000
,, ,, pasteurising coil, 155° F. . .	18,000	360,000
,, ,, first cooling coil, 75° F. . .	33,000	1,020,000
,, ,, second cooling coil, 64° F. . .	2,160,000	3,780,000
,, ,, after bottling, ready for consumer	2,880,000	45,900,000

II

Material examined.	Count per c.c.	24 hours later. Count per c.c.
Milk from original can	42,666	300,000
,, ,, first tank	340,000	700,000
,, ,, second tank	620,000	3,420,000
,, ,, pasteurising coil, 158–160° F. .	16,800	240,000
,, ,, first cooling coil, 78° F. . .	19,666	420,000
,, ,, second cooling coil, 34° F. . .	178,666	1,560,000
,, bottled, ready for consumer . .	446,000	2,880,000

Pasteurisation, when properly carried out, reduces the number of bacteria, and thus preserves milk for a considerably longer period than would otherwise be the case. If badly or insufficiently done it may, as shown above, actually increase the number of bacteria present, or it may engender a false security. In this country milk is supposed to be sold raw, but in fact a great deal of milk has been pasteurised before sale. In other countries, as on the Continent and in America, where the sale of pasteurised milk is definitely known and permitted, large central stations have been established, and the milk is brought there direct from the surrounding farms, is pasteurised in bulk, and sold as pasteurised milk. In England, a few large dairies and some societies have a pasteurising plant which can deal with their own or a part of their own milk supply. A great

[1] McClintock and Pennington. Quoted by Eastwood, Report to the L.G.B. New Series, No. 1, 1909.

deal of pasteurisation is carried on by small dealers, who apply heat in order to make the milk keep till the next day, or longer. The milk may even be heated on two separate days.

Thus, it may become merely a device to enable milk to be sold as raw milk at a later period than should be the case. If milk which has been pasteurised becomes reinfected, the bacteria grows more rapidly than in raw milk, and, if such milk is handled in the careless way common in this country, it will certainly receive fresh accessions of bacteria.

Most complex fluids, including milk, undergo chemical changes on standing or on keeping, also with much shaking or jolting. Although the precise nature of the changes is not known, there is evidence that stale milk, even if not soured, has undergone changes. Many housewives rightly make a practice of heating their milk for the household as soon as it has been delivered. If milk which has been pasteurised is sold as raw milk it will be heated again in many houses and will thus have been heated twice before consumption. Of recent years, with the introduction of pasteurisation on a large scale, it has been found that milk which has been heated twice is not a suitable food for infants, having a tendency to induce infantile scurvy. It is not known how far such tendencies are due to the long interval which will almost certainly have elapsed between the drawing of the milk and its consumption, or how far the second heating may be the detrimental factor. More precise knowledge, while of interest, does not affect the general point, and it should be clearly borne in mind that artificially fed infants, whose sole food is milk, should not be given milk which has been heated on two separate occasions.

If pasteurised milk is sold as raw milk there is a very good chance that it will be again heated in the home before being given to the infant, which is most undesirable. There can be no doubt that milk delivered for infants should be delivered raw, both in order to ensure that it is as fresh as may be possible, and also to prevent a second heating.

The American regulations for the sale of milk very rightly insist on such milk being regarded as unfit for infants.

For adults and cooking there are great advantages in the sale of pasteurised milk. It has been shown in Chapter XVII that the anti-scorbutic value of milk is very small, and it is unnecessary, in view of the mixed dietary of individuals older than infants, to rely upon milk for the supply of this factor. The milk keeps longer, and, if the pasteurisation is well carried out, ensures freedom from germs of disease. Unfortunately, if the pasteurisation plant should be out of order, the milk may be sold as pasteurised when it is really raw, and possibly infected. An example of this was furnished on a large scale in Chicago a few years ago. A widespread outbreak of sore throats suddenly arose, which rapidly subsided, showing, however, a further rise a few days later. The number of persons attacked is given as 10,000, and it was believed that this was much too low : a number of deaths occurred as the result of the epidemic. The cause of the outbreak was traced to a dairy, and it was found that on each occasion, a few days before the outbreak, the pasteurising plant had not been in order. The contamination was due to streptococcal infection, and was traced to an outbreak of mastitis in the cows of one of the farms supplying the dairy. An interesting point arises in the fact that the same mixed milk was supplied raw to a children's hospital, where the pasteurisation was done on the premises. The hospital staff, however, were supplied with milk pasteurised at the dairy. None of the patients suffered from any disturbance, but many of the nursing staff were attacked. It is evident that if pasteurisation is carried out on a large scale, and the milk sold as pasteurised, proper precautions must be taken to guard against a breakdown of the apparatus.

Taking all the points into consideration, it is probably advisable to arrange for proper pasteurisation of the whole milk supply at large dairies, under proper supervision. The milk so treated should be sold as " pasteurised," and it should be clearly stated that it is unsuitable for infants. In

Chicago it appeared that the pasteurised milk was not sold until some two or three days after it had been heated, and this no doubt would be a common practice with a system of commercial pasteurisation. This alone renders it highly undesirable for infants. It cannot be too emphatically stated that milk for infants should be delivered as soon as possible after milking, and should be raw when delivered.

The use of heated, as against raw, milk is discussed in Chapter XXVI, and in the present chapter it is assumed that milk should be heated, in order to destroy any pathogenic organisms which may be present.

Pasteurisation in the home is carried out on a different plan from that on a large scale. It is preferable here to place the milk in a suitable receptacle, and the receptacle in a pan, where it is surrounded by water. The surrounding water should be cold to start with, and should be allowed to rise to the boil and remain boiling for not more than two or three minutes. Only milk which is to be used for infants or for drinking purposes need be so treated; that for cooking will be heated in the process of cooking.

If the milk is for persons other than infants on the bottle, it is best heated, either in a double saucepan or, failing this, in a covered receptacle which is allowed to stand in a saucepan of water. The receptacle used should be thoroughly cleansed with hot water and soda; rinsed with hot water (preferably boiling) and then placed to dry, *bottom upwards*. It should not be dried out with a cloth, but allowed to drain. If a double saucepan is used, the inner pan should be kept for milk only. If a receptacle in a saucepan is used, the receptacle must be covered either with a closely-fitting lid or a piece of gauze, or, if the neck be narrow, it may be lightly plugged with a piece of cotton-wool; the water in the outer pan should then reach as nearly as possible up to the level of the milk in the receptacle.[1] In a double saucepan the

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[1] If the receptacle rests on the bottom of the saucepan it is apt to bump in boiling; this is avoided if it be placed on a stand around and under which the water can circulate freely. Such stands can be purchased under the name of saucepan guards.

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level of the water is of no account, as the temperature rises in the apparatus as a whole. After the water has boiled for not more than three minutes the inner pan or receptacle should be taken out and placed to stand *at once* in a basin or other vessel of cold water. This water will become warm in a few minutes, and should be thrown out, and fresh cold water supplied. In hot weather it is advisable to change the water every few hours. On no account should the milk be transferred from the vessel in which it has been heated to another ; the vessel has been partly sterilized by heating, and the milk should be kept in it, portions of milk being poured out of the vessel as they are required for use. Further, the milk *should be kept covered*, both during and after heating, the cover or plug only being momentarily removed to allow of some of the milk being poured out. If the cover is removed while the milk is hot, a skin will form, and, also, will allow dust and dirt to blow in. As has already been mentioned, milk is a fluid which both heats and cools slowly on account of its low power of conduction. When the water outside is boiling the milk has not reached that temperature, and does not reach 100° C. until the water outside has been boiling for a considerable time. In order that a temperature sufficient to destroy the pathogenic bacteria should be reached in the middle of the pan, it is advisable not to have a pan or receptacle that is too wide across. If a double saucepan is taken it should not contain more than three pints. This, however, will probably suffice for any but a large household, since the milk for cooking would not be heated in this way. Again, a longer heating than the above will affect the cream ; two or three minutes in boiling water does not affect the rising of the cream, but five to ten minutes spoils the cream-line.

If the milk is for infants on the bottle, it is advisable to prepare the milk mixture first of all, and to fill as many bottles as are required for the feeds (and if possible an extra one for safety, in case one should break), and to place these on a stand in a pan. The bottles should have the necks lightly plugged with cotton-wool, and the water outside

should reach the level of the milk inside. The heating is carried out as already described, and the bottles, after heating, are plunged at once into cold water. Occasionally one will break, but not often. When required for the child the plug is removed, and a teat put on, the whole being placed in warm water for a minute or two to take off "the chill." The heating should be done only once in the twenty-four hours, and, if properly carried out and the milk kept cool, there will be no difficulty from the souring of the milk.

The whole process is most simple, and only requires reasonable care and intelligence. The author has frequently explained the process, but too commonly people either persist in boiling for a longer period, when the milk tastes boiled and the cream-line is affected, or they seem unable to keep the milk covered, and equally unable to refrain from the temptation of pouring the hot milk into another receptacle, generally a jug. This, while clean in appearance, has probably been dried out with a tea-cloth or other rag which is loaded with bacteria, therewith reinfecting the freshly heated milk. In such circumstances, also, a skin is formed on top and, further, the milk does not keep well. It is much simpler just to keep the milk covered in the receptacle in which it has been heated. Fig. 53 shows a suitable apparatus for the home pasteurisation of infants' milk, but much simpler arrangements can readily be devised.

There is little advantage to be gained by prolonging the period of heating. The great mass of bacteria are destroyed in the first few minutes. Ayers and Johnson [1] showed that, even at a temperature of 130° F., the living bacteria were reduced in the first half-hour from 2,530,000 to 75,000, while a further heating for $2\frac{1}{2}$ hours only brought about a reduction to 9,200. At a temperature of 140° F. the reduction effected in the first half-hour was from 2,330,000

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[1] Ayers and Johnson. (1) "Ability of Streptococci to Survive Pasteurisation," *Journ. of Agric. Res.*, 1914, vol. ii, p. 321 ; ·(2) "A Study of the Bacteria which Survive Pasteurisation," *Bureau of Animal Ind., Bull.*, 161, 1913.

to 20,000. It is probable that the majority were destroyed in the first few minutes.

In the process of condensing milk for sale as condensed milk the pathogenic bacteria are destroyed, and the non-pathogenic ones are in great part killed by the prolonged heating, and are then prevented from multiplying by the sugar added as a preservative.

When milk is dried, although the rollers over which it is passed in the more usual processes are heated to 120° C.,
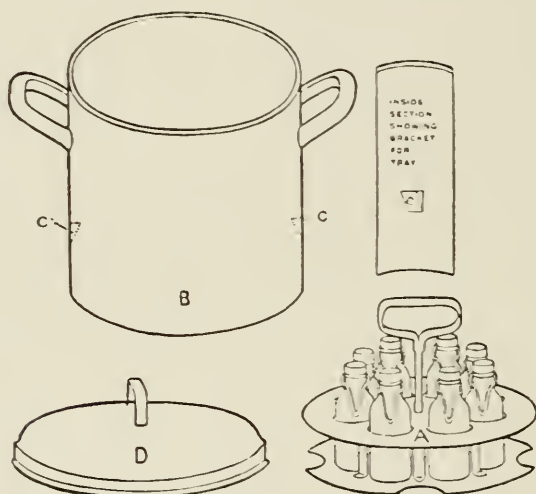
FIG. 53.—An apparatus for home pasteurisation.

Délépine [1] found that the temperature of the milk, as it dried, probably did not exceed 96° C., and that the time of exposure to this temperature was not more than 3·3 seconds. In samples of milk artificially infected with tubercle bacilli he found that some still survived after heating. For practical purposes, however, it may be assumed that dried milk is free from pathogenic bacteria, and that the other forms have been sufficiently reduced to be neglected. Also, they do not multiply in the dry material.

[1] Report to the Local Government Board, New Series, 97, 1914.

CHAPTER XXIII

THE FEEDING OF INFANTS

DURING the first few months of life the human infant should be fed on milk only. The young of all the mammalia have this fluid, which contains all that is required for their sustenance, during a varying period after birth, provided for them by nature. The young of different species are born in varying stages of maturity, and the length of time in which they are wholly dependent upon their mother's milk varies with it. For example, guinea-pigs are born in a high state of maturity. Within not more than a few hours, and often within a much shorter period, they are running about actively in the cage eating anything they can find. They generally have, at any rate, a few teeth well developed at birth. Such animals are not wholly dependent upon their mothers' milk for more than a very short period, although they avail themselves of it for some days.

In the human species the infant is born in an immature state and requires its mother's milk for several months until its masticating and digestive apparatus has got into a sufficiently developed condition to be able to utilize other foods.

A fluid dietary is clearly indicated until such time as the infant's teeth are sufficiently developed to be able to bite solid food. When this time arrives, which should be about the eighth month, the milk ceases to be suitable as the sole food. Again, the digestive apparatus is best adapted for milk during the early months, but later is able to deal with other substances.

This capacity would not appear to be dependent only upon the presence or absence of ferments in the several parts of

the alimentary canal, since all the ferments afterwards required are present not only at birth, but in many instances for some time before birth. The saliva contains ptyalin at birth, and is capable of splitting starch, although its power of doing so is weak. This power does not increase until about the sixth month of life, after which it is said to be stimulated by the presence of starch in the food. General experience has shown the inadvisability of giving starch to young infants, and it may safely be assumed that, had any such substance been necessary, nature would have provided for it. The presence of a weak ferment in the saliva does not therefore mean that the infant should be given food which will utilize it, and neither is it necessary or even advisable to give starch at the first moment that the ferment becomes present in more powerful form, namely, at six months of age ; it is usually better to wait for a further two, or even three, months before definitely adding starch to the diet.

Gastric digestion also takes place in the young infant, but the amount of acid found is very small, or it may be absent. The most pronounced action is that of rennin, but pepsin is also present. It is, however, difficult to suppose that these are functioning normally during the few days after birth, since during this time proteins must be absorbed unchanged, as will be explained, in connection with the transference of immunity (see below).

Pancreatic ferments are present in the pancreatic juice, although in smaller amounts than in later life. Intestinal ferments appear to be similar to those of the adult with one important exception. A special ferment, lactase, is found in the intestine of young mammals ; it splits lactose with great facility. The ferment is present before birth, and persists for some time afterwards ; but it gradually disappears, and is not capable of being re-established. The ferment apparently ceases to be secreted when the age of a mixed dietary arrives, and cannot be brought back by giving even large quantities of lactose.[1]

[1] Cp. Plimmer, *Journ. of Phys.*, 1906, vol. 35, p. 20.

Provision is thus made for the digestion of all the food-stuffs in the milk. The differences in composition of human and cow's milk is shown on page 228, and also the alterations in composition with the stage of lactation. The importance of the lacto-globulin was pointed out, since it is to this portion of the protein that the immune substances are attached. Much work has been done in the transference of immunity and our knowledge is fairly complete. There can no longer be any doubt that whatever immunity is found in the blood of the mother passes out into the milk by means of the globulin to which it is attached and is taken up unchanged into the blood of the offspring. The immunity thus conferred is of the passive variety, and is transferred in a much weakened form. The strength of immunity in the milk has been estimated in certain cases and found to be between one-tenth and one-fifteenth of that of the blood. The experimental work which has been carried out has been done by producing in the mother an acquired immunity to some known body and studying the transference of the substances formed in response in the mother's blood.

It has already been explained that the proteins must be absorbed directly without digestion for the purpose of this transference, but it is very important to note that the protein absorbed should be that of its own species. Foreign protein is absorbed, but causes considerable disturbances. An artificially fed infant suffers from the foreign protein which it has to take in. The period over which this ingestion can occur is short, being probably not more than a few days, after which digestion becomes established and the protein is broken down with the destruction of the associated immunizing properties. Although this particular advantage of early breast-feeding ceases, it does not mean that artificial feeding may safely be undertaken after the first few days. Quite apart from the differences in the relative quantities of the food-stuffs, the salts vary widely. Thus, in human milk there is about three times as much iron as in cow's milk, while the amount of calcium is much less, and the total quantities of salts are also well below those found in cow's milk. The

true value and function of the various salts still require
much investigation ; but it is safe to say that, as such investi-
gations are made, they will show clearly that hitherto
insufficient importance has been attached to salts in relation
to the general growth and well-being of the infant. The
presence of excess calcium in cow's milk is easily understood,
since it has long been known that the calcium is attached
to the caseinogen as calcium caseinogenate ; there is from
two to three times as much caseinogen in cow's milk as
in human milk, so that a large increase in the total amount of
calcium in cow's milk might be expected. Iron has long
been realized to be of vital importance to the organism.
Bunge, working with the older methods of estimation of iron
in milk, believed that the fœtal liver had a store of iron
which at birth was gradually used up, and necessarily so,
owing to the small amount of iron present in the food,
namely, in human milk. Later researches with more accurate
methods have, however, shown that the amount of iron
really present is much greater than originally supposed.
It may well be that this mineral forms one of the main
differences between the salts of human and cow's milk and
has an important bearing upon the nutrition of the infant.
Magnesium must not be left out of consideration, but at
present nothing definite as to the amounts present or as to
its function is known ; but it is not unlikely that it may
prove to be almost as important, if not as important, as iron.
Of recent years the use of inorganic metals in treatment of
disease has come much to the fore, and even small quantities
have been found to be very powerful drugs, having intense
effects on the body tissues.[1]

The protein of cow's milk and that of human milk will
differ in their composition—that is, in the constituent amino-
acids of which they are made up. It seems that, so far, only
scanty investigations have been carried out upon this point,
which may, however, be one of some importance.

The infant organism has a wide limit within which it can

[1] The references to the literature on iron and other salts, up to 1916,
can be found in *Milk, and its Hygienic Relations*, Lane-Claypon, chapter iv.

work satisfactorily, and theories do not always agree.   For
example, experts are not agreed as to the harmfulness or
otherwise of the excess protein of cow's milk.   It is usual to
dilute milk, so as to reduce the protein to that found in
human milk, but this does not by any means effect a similarity
of protein.   Others, again, do not consider that the excess
protein has any deleterious effect, provided that a salt,
usually sodium citrate, be added to prevent clotting in the
stomach.   Lusk points out (*The Science of Nutrition*,
third edition, page 400) that the excess protein must exercise
its specific effect and stimulate the infant's metabolism, thus
increasing the amount of heat production and presumably
heat loss.

The distribution of calories is very different in human and
cow's milk.   Lusk, quoting from Rubner (cp. Lusk, loc. cit.,
p. 399) points out that if the average composition be taken,
the calories are distributed as follows :

	Cow's.	Human.
Protein	21·3	7·4
Fat	49·8	43·9
Milk-sugar . . .	28·9	48·7
	100·0	100·0

Nothing is definitely known as to the presence or absence
of accessory food factors in human milk.   It may be assumed
that they are present, as is the case in cow's milk, but the
amount is entirely unknown.   It is almost certain that it
will vary with the dietary of the mother, and it is quite
possible that the unsatisfactory progress of infants on the
breast may sometimes be due to an unbalanced dietary in
the mother containing insufficient amounts of the growth
factors, fat-soluble A and water-soluble B.

The value of breast-feeding is well known in practice, and
hardly needs support from the theoretical side.   But it is
hoped that the above remarks give some grounds for the
general experience that mother's milk must be regarded as

the right food for infants. Recent researches, to which
further reference is made on page 289, show that the diet of
the mother has far-reaching effects on the health of the
offspring.

Although, as is shown in the preceding paragraphs, our
knowledge of the composition of milk and its precise relation
to nutrition is still deficient, certain facts bear abundant
testimony to the advantage of breast-feeding. If ordinary
observation did not suffice, the figures of sickness and death
among breast- and artificially-fed infants would do so. The
proportion of deaths from such causes as have been in-
vestigated from this point of view shows that the chance
of survival of the breast-fed baby is many times greater than
that of its artificially-fed brother. In particular the question
of summer diarrhœa has been repeatedly investigated, and
each time it has been shown that the mortality from this
cause is far higher among bottle-fed babies than among
those fed naturally. Those who have to deal with infants
know well that in case of serious illness, the breast-fed baby
may pull through where the bottle-fed baby will succumb.
The risks suffered by contamination of the food are forcibly
shown in fig. 54.

Some years ago it was very widely stated that evidence
was available to show that the capacity of breast-feeding
was diminishing among women. There seems to be no
foundation whatever for this statement, which contravenes
the known trend of nature—fundamental functions are main-
tained by the organism even under adverse circumstances.
Reproduction and the action of the organs associated with
the system will presumably survive as long as the species
concerned. It is unlikely, therefore, on *a priori* grounds that
there will be any failure of mammary function. But there
are pitfalls in the question of breast-feeding which are not
foreseen, and which may lead to a failure to feed naturally.
Under primitive conditions it may be found that the diffi-
culties are less likely to occur than in our present artificial
state. The supposition that primitive races do not suffer
from disease and live long is, however, certainly a fallacious

The Long
VERSUS
The Short Haul

A great number of babies get their food through a tube many miles in length.

It often takes a day and a half for the milk to run from the cow end of the tube to the baby end of the tube.

This tube is open in many places and baby's food is frequently polluted. It is often wrongly kept in over-heated places.

There may be a diseased cow at the country end of the tube.

And yet some People Wonder Why So Many Babies Die!

On the other hand the mother-fed baby gets its milk fresh, pure and wholesome—no germs can get into it.

To Lessen Baby Deaths let us have More Mother-Fed Babies
You can't improve on Nature's Plan.
For your Baby's Sake Nurse It

FIG. 54.—Copies of the above as a poster enlarged to $16\frac{3}{4}$ by $10\frac{3}{4}$ inches, mounted on a stiff card, varnished and with cord to hang, price 2/6 each, can be had on application to the Hon. Secretary, The National Clean Milk Society (Incorporated), 2 Soho Square, London, W.1.

one, as is shown by the published statements and investigations made by travellers.

In England, before the introduction of artificial feeding, if a mother would not or could not feed her infant, she engaged a wet-nurse to perform the duty in her place. This practice gradually fell in disrepute with the introduction of syphilis, since this disease is transmitted by suckling. A syphilitic wet-nurse will infect a non-syphilitic child. Her own child will be already infected *in utero*, but someone else's healthy child can be infected by the milk. Women who have been infected with syphilis often show no symptoms at all, and it is not easy to ascertain whether they are infected or not without rather elaborate pathological investigations. For these reasons the practice of wet-nursing has been discontinued in this country, although it is still used among some of the continental nations. For the most part the wet-nurses are obtained through maternity institutions where the woman can be carefully investigated for possible syphilitic infection.

Nothing can replace human milk for certain classes of ailments. In some conditions a baby may be restored to a good state of nutrition if it can receive human milk for even a short period, whereas it will have little chance of life if it has to be kept on cow's milk. Some maternity institutions abroad obtain milk from women whose supply is more than enough for their own children ; in order to prevent the possible transference of any infection, the milk may be heated before being given. Such a process seems to have no effect whatever upon the nutritive property of the milk, but unfortunately the results obtained have never been published, and are not therefore generally available.

Satisfactory breast-feeding can be secured only by co-operation between the mother and the child. The gland will not work without adequate stimulus, which must be supplied by the child, nor will it work without suitable care of the rest of the body, which depends upon the mother. The first difficulty in breast-feeding is that of getting the gland into working order. Milk is secreted under pressure,

and the interior of the gland shows a positive pressure. The infant grasps the nipple with its lips and compresses it with the object of overcoming the muscular tone of the unstriped muscle tending to close the orifices of the ducts. At the same time the cavity of the mouth is enlarged by drawing down the jaws, which produces a sinking of the floor of the mouth and consequent decrease in the pressure in the mouth. There is then a pressure head between the interior of the gland and the mouth of the infant, which in normal cases should be sufficient to produce a flow of milk. If the child is weak and fails to be able to grasp the nipple firmly, or to produce a reduction of pressure in the buccal cavity, the milk will not flow properly, if at all. A weakly baby may take a long time to get the gland into working order, or may fail altogether. In such a case the fault is usually laid on the mother, who is said to have no milk, whereas the fault is with the infant, who cannot suck with sufficient energy. It is stated [1] that the pressure in the gland increases with the number of children. This may account for the difficulty often experienced with first babies, in cases where the second child finds no difficulty in obtaining its food. If a strong child be placed to the breast for a few days it will often get the breast into good working order, when the weaker child will be able to feed itself adequately. If this be impossible, it may be necessary to supplement the breast-feeding with some artificial feeding until the child is strong enough to suck more firmly. It should, however, be put first to the breast while hungry, and only receive other food after it has obtained all it can from the breast. The infant nearly always obtains more from the breast than can be got by any artificial means such as a breast-pump, and the amount obtained can be measured by weighing the child in the same garments before and after each feed.

The effect of stimulus on the gland is shown by the amount of milk yielded by wet-nurses. These women can often feed two or three infants, as is also not infrequently the

[1] Cp. Fieldman, *Ante-natal and Post-natal Child Physiology*, pp. 448–52.

case with twins. Foreign authors have collected a great
mass of evidence on this point, but among the most
complete are the observations of Budin. The results
obtained with one of the wet-nurses investigated are given
in the following diagram, fig. 55, where it is shown that
this one child took only some 500–800 cubic centimetres of
the total yield of 1,000–2,500. The drop in supply which

FIG. 55.—Showing the amounts of milk yielded under varying stimulus,
owing to changes in the number of infants fed. The lighter shading shows
the amount taken by the wet-nurse's own child. The darker shading the
total amount taken by the other children.

occurred when the number of children fed was reduced is
particularly interesting.

When more than one child is fed care must be taken
that the same child does not always get either the first
milk or the end-milk ; the fat of the end-milk is necessary
for each, and too much fat produces digestive disturbances
which may be serious.

The position of the infant when feeding is of great impor-
tance. It must be held comfortably, so that it feels perfectly
supported, and care must be taken that its nostrils are not

pressed against the gland. If this is so, then the child cannot breathe, and will be obliged to take its head away to avoid being suffocated. If necessary, the gland must be held back from the nostrils by the mother's free hand. Infants sometimes have a tendency to choke during feeding. This may mean either that the child is not comfortably placed for respiration, or that it is taking the milk too quickly. The former can be remedied by seeing that it can breathe satisfactorily, and the latter by controlling the flow of milk. The mother can place two fingers, one on each side of the nipple, and then control the flow, so that the child cannot swallow it too quickly.

Babies should not vomit after feeding. If they do, it usually means that they have either taken too much or too quickly, or that they have not been kept quiet after feeding. If the infant has " wind," it may be gently placed in a sitting position, but its back should not be patted. This last will perhaps help to relieve the wind, but will probably cause vomiting. The practice of placing the child over the shoulder is satisfactory as regards position, if care be exercised, but the patting of the back which usually accompanies it has not equally good results. The object is to allow the air in the stomach to rise to the top of the organ and thus gain exit.

The child should be hungry when it begins the meal. If it is not, it will suck half-heartedly and will only take the first part of the milk, which will flow easily. This is bad for both the gland and for the infant. If the gland is not emptied the milk supply tends to fail : it is not being worked, and this tends to a reduction of function. Then, if only the first milk is taken, the child obtains little or no fat, and does not thrive, since the bulk of the fat is in the end-milk (cp. page 231).

If the child is not hungry it is better to let it wait till the next feeding-time. The infant should not be left at the breast for more than 10–15 minutes. If it is hungry it will have taken all it needs in this period. If not, it is better to let it wait until the next feeding-time. It is not

good to allow the child to go off almost to sleep with the nipple still in its mouth.

There is some difference of both opinion and practice in regard to the best intervals of feeding, and it is probable that it is unwise to advocate any one hard-and-fast rule for all cases. Much will depend upon circumstances, but it may safely be said that the intervals of feeding should in no case be less than three hours (weakly, premature children excepted) and that there should be an eight-hourly interval during the night. With an average healthy child and mother, four-hourly feeds are the best, and can be commenced from birth. Some people find it difficult to believe that a child requires time for digestion, or that its organs want rest, like those of older persons. They have an idea that the more milk the child gets the faster it will grow. This is only correct up to a certain point, beyond which indigestion will result. The breast-fed baby has distinct advantages on these points, since it is less easy to over-feed it than the bottle-fed baby. But if the breast baby is not hungry, the gland will not be emptied, as described above. It will not be hungry unless the stomach is allowed time for digestion, and for subsequent rest.

Human milk does not form a clot with rennet, and the milk does not therefore necessarily remain long in the stomach. The child's stomach can be studied with the X-rays, without the use of bismuth, and it has been repeatedly shown that milk begins to pass out of the stomach even while the child is still feeding at the breast. The stomach of the infant is somewhat more upright than in the case of the older child or adult, which allows the milk the more readily to pass out into the intestine. The amount of milk taken by the breast-fed baby is not dependent upon the size of its stomach, since a portion at any rate passes through to the intestine during the period of feeding. Some gastric digestion takes place, however. There is no fixed period within which digestion takes place, since the period depends upon the composition of the milk and is delayed by the presence of fat. It would seem that from two to

three hours may be regarded as a fair average time.   Four-hourly intervals between the feeds give the stomach some rest.   The eight-hour interval at night enables both the mother and child to get a prolonged and unbroken period of sleep.   This is good for both, and, by conducing to general good health on the part of the mother, helps in securing the activity of the mammary gland.

The mother also has her part to play in breast-feeding. She must preserve her body in a good state of health, if the gland is to do its share.   The supply of breast-milk depends upon adequate nourishment, and the mother's dietary is a matter of importance.   It should be varied, but need not otherwise differ from that eaten when nursing is not under-taken.   There is no food which need be forbidden a nursing mother, except those which cause her indigestion.   She should be encouraged to take vegetables and other articles of a mixed diet, so soon as she feels able to do so after the confinement.   A diet of bread and tea is unsatisfactory. It is deficient from almost every point of view.   If large quantities are taken, enough energy may be supplied at the risk of producing indigestion and other troubles.   A dietary too rich in protein appears to have an adverse effect on the milk-supply, and to reduce or even prevent its formation.[1]   This is, in fact, in accordance with general experience.   The well-to-do nursing mother who is over-fed often loses her milk.   It is then said that she is incapable of breast-feeding and that it is useless to attempt it again. Most people recall the pressure often brought to bear on the young mother to eat more, because she is nursing the baby.   The result too frequently is that the mother lays on a good deal of fat, which annoys her, as she thinks she is losing her figure, and the breast-milk fails.   If she had eaten a normal varied dietary, there would probably have been no difficulty.   There is no need for a mother to avoid active exercise while nursing, so long as the exercise is not carried to fatigue.   It is important to keep the bowels open by exercise and suitable diet rather than by drugs.

[1] Hartwell, *Biochem. Jour.*, 1921.

Breast-feeding should not be abandoned without more effort than is sometimes made. The breast will often come into good working order as late as one month after the birth of the child ; persistent efforts should be made for not less than four weeks. Again, if breast-feeding has been given up, for one reason or another, it can very frequently be restored, even after several weeks. The inherent capacity of the gland for its function is far greater than is commonly attributed to it—that is, if it is treated properly. Due regard must be had to the whole position ; the mother's food, the infant's method of feeding, and so forth, require taking into consideration.

The mental outlook is also important. The fretful, worrying mother is not often a good nursing mother. She neither gives herself nor the child any real repose. The child wants quiet and calm to enable its processes to be carried out satisfactorily. The agitated mother, always on wires, always in a hurry, makes the child fretful. Sooner or later the general effect is that it ceases to thrive, and the mother's milk is said to be at fault. Really it is the mother's habits. The peaceful ten to fifteen minutes which should be devoted to breast-feeding at each meal is good for the mother ; it makes her rest, and induces a calm attitude of mind, which will greatly help in her work and be of benefit to her general health.

There is some divergence of opinion in regard to the need for regularity of feeding ; if the intervals are to be quite regular, then the child must be awakened at first at any rate. After a short time the infant will wake itself very regularly for its food, and, in any case, it will probably go off again to sleep after the food. Others, however, consider it most undesirable to wake the child, and think that it should be allowed to fix its own hours for meals, provided always that the interval is not less than four hours. Probably in practice there is less distinction than appears, since the infant will wake at more or less fixed times if accustomed to them, and the demands of the stomach will tend to some degree of regularity. Some regard must, however, be paid
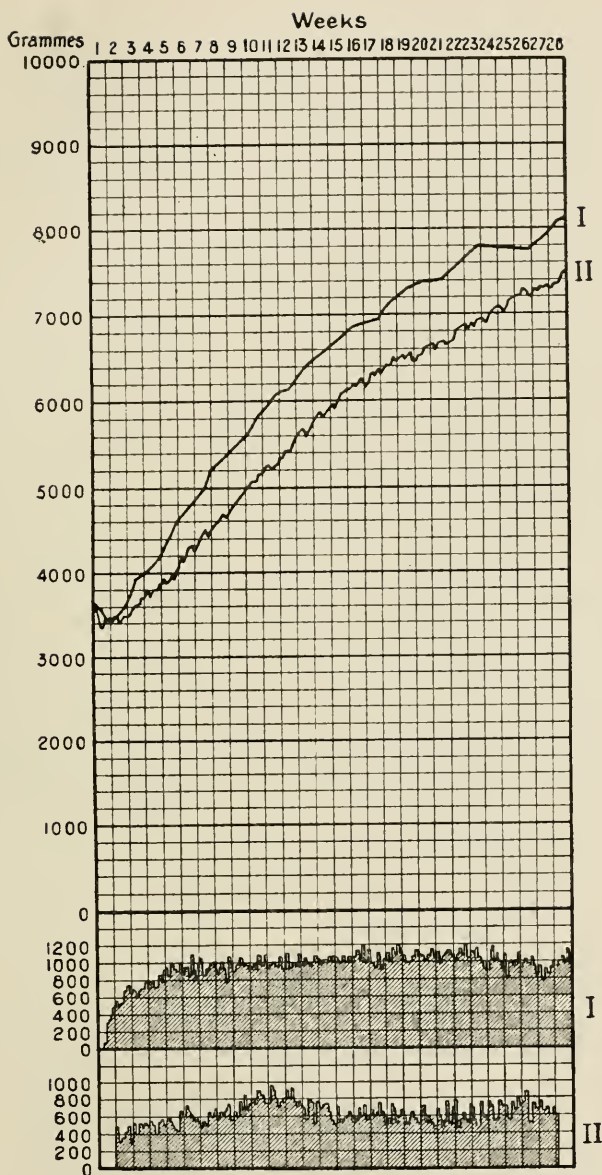
FIG. 56.—Showing the weight-curves and amounts of milk taken by two breast-fed infants.

to the mother and to her duties. It is often impossible for the mother to wait for the baby to awaken, if the sleep is long. Her occupation may require greater regularity, and the breasts may become painful and require emptying. Some common sense must be used, bearing in mind the general requirements, as set out above.

The amount of milk taken by healthy breast-babies varies considerably. Abundant evidence is available from foreign sources showing precisely the amount of milk taken at each feed throughout several months of life. The child was weighed before and after each feed throughout the entire period. Among the most complete are cases given by Czerny and Keller, and two of these are shown in the accompanying diagram (cp. fig. 56).

It should be noted that the general rise of both weight-curves is good. Further, that the amount of milk taken rises rapidly, reaching a maximum during the first few weeks of life, and continuing at the same level throughout the period of observation. The amounts of milk taken by the children show a greater difference than the weight-curves, Child I taking not far from twice as much milk as Child II.

The child needs more food during the period of rapid growth in the early weeks of life, but such amounts cannot be given to the artificially fed baby, because the conditions of digestion are different. If the same amounts of modified cow's milk were given as are safely taken by the human infant in the early weeks of life disastrous consequences would occur. This is considered more fully in the next chapter.

In regard to the amounts taken by breast-fed babies, it may be remarked that 600 c.c., which was often taken by Child II, amount to approximately 1 pint of milk, or just over 21 oz., since 1,000 c.c. or one litre $= 1\frac{3}{4}$ pints, or 35 fluid ozs., and was repeatedly taken by Child I. These quantities are greatly in excess of what could be safely given to or taken by an artificially fed baby in the first few months of life.

CHAPTER XXIV

IF breast-milk fails, or is insufficient, cow's milk must be provided for the infant ; goat's milk will also serve, if this is available. Ordinarily, however, cow's milk in one form or other is provided. In this chapter only some of the more generally important modifications of cow's milk will be dealt with. There are numerous more highly specialized modifications, and milk mixtures which are used by specialists dealing with children. These are, however, outside the sphere of a work like this, as they are unnecessarily complex for use for the ordinary reasonably healthy infant.

The most usual modification is that which is carried out with the object of bringing about an approximation of the composition of the cow's milk to that of human milk. For this purpose the milk must first of all be diluted by means of an equal volume of water in order to reduce the protein from 3 per cent. to 1·5 per cent. This makes the sugar and fat too dilute, and additions of these must be made to the fluid. The amounts of these added can vary slightly, but an average milk mixture can be made by taking $\frac{1}{2}$ pint of milk (10 ozs.), $\frac{1}{2}$ pint of water, 2 tablespoonfuls of lactose or one of cane-sugar, and 1 oz. of cream. The tablespoonfuls should not be heaped. The amount of lactose in such a mixture will be roughly approximate to that in human milk, while the fat is rather below the percentage in human milk. It is not advisable to give as much cane-sugar as lactose, and some people do not consider cane-sugar at all satisfactory. It has been found in practice that milk is best diluted until the child is about six months old. Some people consider that if a child has to be artificially fed during the first two

or three weeks of life the dilution should be carried further than equal parts of milk and water : in some books even as high a dilution as one part of milk to three or four of water is recommended. There seems to be no reason for so much dilution, which will probably not supply sufficient nitrogen for the child. It may be remembered that colostrum is especially rich in nitrogen, so that it may be assumed that the child needs a considerable amount of nitrogen in the early weeks after birth.

If the milk be diluted beyond that represented by the amount present in the later milk of the human species it is doubtful whether the amount can be considered sufficient. The loss of weight during the early days (cp. pages 320–321) is greater in the artificially fed infant than in the breast-fed baby, and this may in part be due to the smaller amount of nitrogen. On the other hand, the protein of cow's milk is foreign protein, and it is probably inadvisable to give more than would be represented by dilution to one-half.

It is neither possible nor advisable to lay down definite rules for the feeding of infants. The body-weight is a better index of the amount required than the age of the child. The development of children varies greatly, and a child, for example, of four months, may often weigh as much as another child of five or even six months, or as little as one considerably younger. Much depends on its inherited characteristics and other factors. Moreover, an active child will consume more energy than a passive one, and hence will require more fuel—that is, more milk. Again, as is pointed out very forcibly by Pritchard,[1] the amount of food required will depend upon the amount of clothing, housing conditions, etc. Some authorities consider that the amount of milk taken should be calculated on the area of surface of the body. This is related to the weight, and becomes proportionately less as growth proceeds. A large number of calculations have been made as to the total number of the calories, and hence the amount of milk required per square metre of surface, and per kilogram of body weight. Hawkins con-

[1] *The Infant*, 1916, pp. 66–75. Published by Arnold.

sidered that during the first three months of life 100 calories per kilogram were required, falling to 90 during the next three months, and 80 or less thereafter. It seems fairly certain that these figures are greatly in excess of requirements, and later work by Murlin and Hoobler,[1] and by Benedict and Talbot,[2] shows that 48 calories per kilogram of body weight is sufficient for newly born infants, rising, however, to 60 calories per kilogram a few weeks later.

General reckonings in calories and kilograms are of little or no assistance to the nurse or mother who seeks some guidance in regard to the amount which should be given. It seemed, therefore, worth while to take the figures and work out the amounts on the following basis :

    1 litre = $1\frac{3}{4}$ pints = 35 fluid ounces.
    1 kilogram = 35 ounces.
    1 kilogram cow's milk = 684 calories.
    1 kilogram human milk = 719 calories.

Further, it is assumed that 48 calories per kilogram are required immediately after birth, and 60 calories at later dates.

Taking infants to weigh roughly 7 lbs. at birth, 11 lbs. at 3 months, and $16\frac{1}{2}$ lbs. at 6 months, the figures given below are obtained :

Weight of infant.	Calories required.	Equivalent of cow's milk unmodified.	Equivalent of milk for modification.	Equivalent after modification.	Amount of mixture per feed, if five feeds per day.
7 lbs.	153·6	8 ozs.	4 ozs.	$7\frac{1}{2}$ ozs.	$1\frac{1}{2}$ ozs.
11 ,,	300	$15\frac{1}{2}$,,	8 ,, (nearly)	15 ,, (nearly)	3 ,,
$16\frac{1}{2}$,,	450	30 ,,	Mixture probably not needed.		6 ozs. whole milk.

These are, in fact, the very quantities that are commonly prescribed as a result of experience. It is very usual gradually to increase the quantity of the mixture up to about 4 or

[1] *Amer. Journ. of Dis. of Children*, vol. ix, p. 81.
[2] *Physiology of the New-born Infant.* Carnegie Institute of 1915, Bulletin 233.

$4\frac{1}{2}$ months of age, after which the degree of dilution can be reduced until the child takes about 6 ozs. of whole milk at each feed at the age of six months. It cannot, however, be too clearly stated that no hard-and-fast rules can be observed in the feeding of infants, and that excellent results are obtained by widely different methods; each baby must receive individual consideration.

Whatever milk mixture is used should be prepared once each day and heated as described on p. 273 et seq. If the child leaves any of its food, this should not be kept for the next time, but a fresh portion used for each occasion. Too often the bottle is temporarily set aside and even put to keep warm by the side of the fire. Sometimes the bottle stays there for prolonged periods, during which the bacteria are being incubated under favourable conditions, and are multiplying rapidly in the milk.

The upright bottles, as shown in the diagram on p. 276, are the simplest to use, because no handling of the milk is required after it has been once heated. The old long-tube bottle has already been utterly condemned as unhygienic, on account of the impossibility of keeping the tube clean, since it cannot be boiled without destroying the rubber. The boat-shaped bottle is satisfactory as to shape, but the milk must then be heated in some receptacle and poured into the bottle before each feed. If this be done care should be taken that the milk is properly mixed before each use, otherwise the fat content of the food will vary considerably. The teats should fit directly on to the bottle. The bottles should be well cleansed with soda and hot water, and then scalded or even boiled; they should subsequently be allowed to cool in such a position that dust does not gain access to the inside of the bottle; they should remain in this position until required for use. The teats require turning inside out and thoroughly cleansing with hot (not boiling) water, placed in boracic lotion for a while, and then left in clean cold water until needed. In selecting the teat, some care should be given to the size of the hole. If too small, the child may not be able to get the food comfortably, and will be fretful;

if the hole is too large, it will take the milk too quickly and may choke or even vomit the food.

Cow's milk, on reaching the stomach, is acted upon by the rennin of the gastric juice, and a clot or curd is formed. This clot takes some time to digest, and the milk is delayed in the stomach for digestion. Human milk does not form this clot, and the milk therefore passes out of the stomach more readily. If an artificially fed infant be overfed, it will usually vomit the excess. Continued over-feeding with cow's milk may lead to a dilatation of the stomach with weakening of the walls and subsequent indigestion.

Dried milk has come very much to the front of recent years as a food for infants, and there is every reason to believe that its use will increase. There is some divergence of view upon its desirability, but most of those who have used it are agreed that it forms a valuable and satisfactory food for infants. A great number of dried milks are obtainable, but some are better known than others. Different processes are used in their preparation. The commonest method is to pass the milk in a thin film between rollers heated to 120° C. or over. The milk is rapidly heated and dried, the water passing off as vapour. The temperature of the milk itself has been shown to remain below 100° C. throughout the period of desiccation, which amounts only to about 3 seconds. Fig. 57 shows the method used.

The drying apparatus consists of two cylinders placed side by side, the space between them not exceeding two millimetres. They rotate in opposite directions at a speed of six to fourteen revolutions per minute. They are heated by steam under pressure at a temperature of 139°–141° C. for whole milk, or rather lower for separated milk. The steam enters through pipe V. The milk enters through pipe L, the outflow through d being regulated. It falls into the gutter a, when it passes into a state of ebullition. The temperature of the milk during the short time it was in the gutter was found to remain below 100° C.

The milk passes out from the gutter in a thin layer, which rapidly dries in a pellicle on the surface of the rotating

cylinder. By the time that two-thirds (approximately) of a revolution has been accomplished the milk is sufficiently dry to be separated in a continuous ribbon by means of the long, straight blades at r. The ribbon falls into the chamber C, whence it is removed, powdered, and packed in tins.
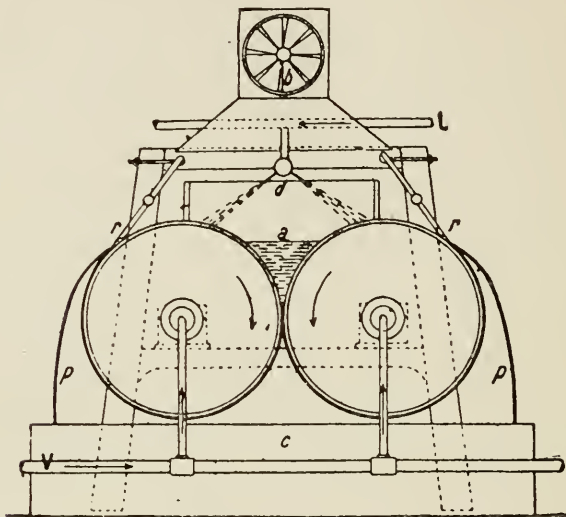
FIG. 57.—A method of desiccating milk. The drying apparatus consists of two cylinders placed side by side, the space between them not exceeding two millimetres. They rotate in opposite directions at a speed of 6–14 revolutions per minute. Steam at a temperature of from 139–141 degrees Centigrade enters through the pipe V. The milk enters through pipe L. The outflow through d is regulated and the milk falls through the gutter a, passing out in a thin layer which rapidly dries in a pellicle on the surface of the rotating cylinder. By the time that the cylinder has gone through approximately two-thirds of a revolution the milk is sufficiently dried to be separated in a continuous ribbon by means of the long straight blades at r. The ribbon falls into the chamber c, whence it is removed, powdered, and packed into tins.

Another method employed is to concentrate the milk to the consistency of a syrup at a relatively low temperature at reduced pressure. The milk is then forced under pressure in a jet through a small aperture, whence it passes to a chamber, where it meets a hot air current under pressure. This process causes the solid portion to fall out as powder.

The advantages claimed for this method are that the milk is kept below boiling point throughout the process; but, on the other hand, it is exposed to a prolonged heating. Practical experience does not seem to have shown any marked difference in the results obtained by the two methods.

The best-known brands of dried milk are perhaps the Just-Hatmaker (also known as the Cow and Gate, and as the West Surrey Central Dairy Co.), and that known as Trumilk. The powder is sold as dried whole milk, and also half-cream milk, and skimmed milk. Glaxo is another very well known variety of dried milk. In using whole dried milk regard must be had to the need for modification.

Ordinary dried whole milk is seven to eight times as strong as fluid milk. In order to restore it to the original strength, one teaspoonful (not heaped) should be dissolved in one fluid ounce of water, and so on in proportion to the amount of milk required. The powder dissolves better in warm water than in cold. The emulsion formed on the addition of water varies a little with the brand. The degree of emulsification is not material to infants, who do not appear to pay attention to these minor points. It is rather the adult who takes the solution in tea who minds whether the emulsion is good or not.

Some doctors prefer the half-cream brand of milk, and others use the skimmed milk, which is cheaper for poorer persons, in which case the addition of fat is necessary. Pritchard uses a fat emulsion known as Marylebone Cream, which contains beef fat, and appears to be a very satisfactory substitute for cream.[1]

The protein of cow's milk is more readily digested when it has been heated than when it is raw, and the protein of dried milk is rather more easily digested than that of pasteurised milk. For this reason it may be possible to give the milk in a rather less dilution than one-half emulsion and one-half water. This is undoubtedly an advantage in special cases, but requires careful usage. Some mothers

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[1] The fat used in the original mixture was linseed oil.

have the idea that an infant should be given as much food as possible. Dried milk commends itself to these as having a more real appearance of food than fluid milk ; hence they make the preparation too concentrated. Some people have had unfortunate experiences with dried milk, but in nearly every such case it will be found that too much food has been given. This leads to vomiting and to a condition of malnutrition ; if smaller amounts are given, trouble is rarely experienced. The directions on many of the tins are misleading, and the amounts directed to be given are too large. It is better to ignore the directions, and to remember that one teaspoonful of the powder represents, roughly, an ounce of whole milk, calculating from this the amount required.

Of recent years there has been much discussion as to the production of rickets or of scurvy by the use of heated or of dried milk. This is discussed further in Chapter XXVI, but it may be stated here that much of the outcry raised is not based upon ascertained facts. If desired, there is no harm in giving fruit or orange juice to any artificially fed infant.

The general position of dried milk for infants has been carefully investigated by Coutts,[1] who showed that its use was attended with very satisfactory results. Special investigations were made as to the weight-curves and general condition of infants fed on dried milk. Some of the curves are shown in the figure below (see fig. 58).

The advantages of dried milk are many. In the first place, it may be taken as free from germs of disease. Délépine, it is true, found that the tubercle bacillus, when added to milk about to be desiccated, was not entirely destroyed ; but, for all practical purposes, dried milk may be taken as germ-free. Such bacteria as are found in samples, when investigated, have most probably been introduced in the later manipulations.

Then dried milk can be kept over prolonged periods. The quantity required can be prepared for each meal, and there

[1] Report to the L.G.B., 1918.

is no waste. Fluid milk must be purchased in definite amounts, and cannot and should not be kept more than twenty-four hours.

In view of the excellent results obtained, it is rather difficult to understand the strenuous objections sometimes raised to the use of dried milk. Practical experience in such a case carries great weight, and should not be set aside by theoretical objections. There can be little doubt that
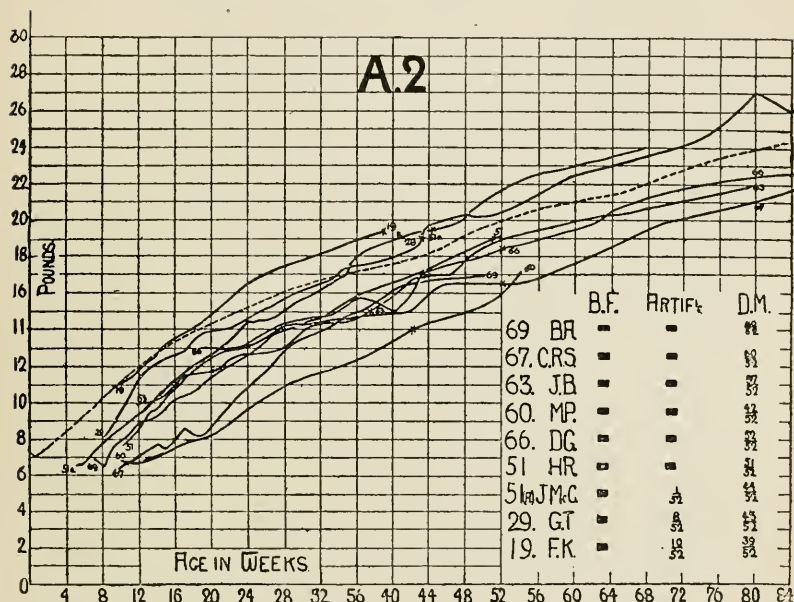
Fig. 58.—The weight-curves of infants fed on dried milk (D.M.). The numbers in the column D.M. show the number of weeks during which the feeding lasted. The dotted line represents the average weight-curve.

dried milk is a great gain for the poorer classes, at any rate, and it is widely used among all classes of persons. It has always a distinctive taste, and is not so nice in tea or coffee as other milk; but the infant, in fact, often seems to prefer dried milk to ordinary milk. Presumably infants have little sense of taste in early life, for, if allowed, they will contentedly take sour milk.

Condensed milk is not suitable as a food for infants,

although it may often be useful as a temporary measure in special cases of intestinal disturbance ; the sweetened variety contains too much sugar and too little fat. In order to give the child the requisite amount of fat, it would be necessary to give it more of the other constituents than it could possibly deal with. The unsweetened varieties do not keep well, and must be used quickly when once opened. Attempts have been made to make up small tins of the unsweetened variety to avoid this difficulty, but they would not appear to have met with great success.

Patent or proprietary foods should not be used. For the poorer classes they are very expensive, in addition to being unsuitable. The majority of them contain starch, which is not good for the infant, and in the few cases where they are practically dried milk under another name there is no advantage in paying the additional price for the sake of purchasing a proprietary food. A few such foods are useful in special cases as temporary measures, but not as a continued diet.

The large amount of sugar or starch in condensed milk and in proprietary foods makes the children very fat, and parents and friends express great delight at the enormous size of the child. The size is due to fat only, and the child is usually unhealthy and flabby, and in addition is frequently rickety. An infant should have firm, rounded limbs, not large flabby ones with rolls of fat. These large children are more liable to bronchitis and other ailments than the smaller and healthier ones. Further remarks on this subject will be found in Chapter XXVI.

THE FEEDING OF CHILDREN AFTER THE AGE OF INFANCY

THERE have been, and still are, very marked variations in practice in regard to the age of weaning. Many years ago it appears that children were frequently not weaned until the end of the second year of life. It is, however, probable that breast-milk was by this time merely a supplementary part of the dietary. Suckling is often voluntarily prolonged at the present day as a result of the belief prevalent among many that pregnancy does not recur while lactation is carried on. This belief, which fails continually in practice, is still clung to by numerous nursing mothers. The occurrence of pregnancy during breast-feeding is not in itself a contraindication to breast-feeding, if the mother is strong enough to carry it on. There is likewise no reason why nursing should not be carried on after the usual time for weaning, provided that the mother's milk is not the only diet, but forms rather a supplement to the other food.

The breast-fed baby can safely be left at the breast for the first eight or nine months, at which age it requires more solid food. It is often advisable, with artificially fed children, to give a little *purée* of apples, carrots, or swedes at or soon after the sixth month. How far the advantage of the *purée* is due to the cellulose, and how far to the juice is undetermined, and is not of great importance from the practical point of view. In infants with a tendency to constipation great improvement is often noticed on commencing the apple or root *purée*. It is understood that the roots or apples will be well cooked and then rubbed through a sieve. One or two tablespoonfuls of it can be given in the day from about the sixth month onwards. If

the baby is doing well there is no special object to be gained in adding to its diet before the eighth or ninth month.

When this age has been reached some solid food must be given. Bread and milk or rusk and milk are most commonly used, and serve very well. The bread or rusks should be pulped in hot milk until quite soft, so that the resulting mixture is fairly thick and smooth. Some children take it best when sufficiently fine to be drawn through the hole of a teat ; others take it quite easily when fed with a spoon, and it is best, if possible, that the child should begin to accustom itself to spoon feeding. It will be advisable to give the bread and milk gradually : for example, one meal of this, say, on alternate days, or three times a week, then increasing up to once a day and then twice in the day in place of a feed of milk.

When the child has got accustomed to the bread or rusks, it may proceed to gravy and mashed potato, and gradually to bread and butter, biscuit, and generally to a more varied dietary. By the tenth or eleventh month the child may usually be given a little egg-yolk, if this can be afforded, say, about a half or one-third of a yolk two or three times a week.

By the end of the first year a diet with considerable variety may safely be provided, including a very little soft fish well pounded up. Milk puddings or custards are good, and fat should form a part of the diet, butter being very good, but at the present time it is unfortunately too expensive for many. Suet is less expensive and can be added in small quantities to a rice pudding, if the last is well cooked, as it should be. The fruit or vegetable *purée* may with advantage be continued. In the early months of the second year the child can take small, well-cooked portions of most of the ordinary foods served for the family. It must be well mashed, as the teeth will not be able to deal with really solid pieces, and the child will not undertake much mastication.

There is no special need for large amounts of milk after weaning. It is good in puddings, and, if it can be afforded,

can be given as a beverage, but it should not be regarded as the main article of diet. When the alimentary canal can take a mixed dietary it is a mistake to provide it only with slops. On the other hand, some discretion must be used, and such things as sausage, lobster, pickles, cheese, raw apples, and so on, should be reserved for a later age. The intestine needs roughage to work on, and too concentrated or nutritious a diet tends to produce constipation. As the child grows older the ordinary diet of an adult may be given in regard to the more usual food-stuffs : highly flavoured, done-up dishes or very rich food is inadvisable and the diet should be plain and good, with sufficient variety. Too often children are given bread and margarine for breakfast and tea, with perhaps a little jam occasionally, and, even if the meat be varied throughout the week, the pudding will usually be a milk pudding, which, however excellent in itself, is monotonous in the long run. Green vegetables, or roots, and potato should form a part of the daily dietary, but they can be served in different ways to give variety. Potatoes should not be peeled ; they should be washed and either boiled or (preferably) steamed in their skins, which can then be peeled off without removing the layers near the skin.

The amount of food required during the period of growth and adolescence is obviously both an important and an interesting subject. Unfortunately, the necessary data are conspicuously absent, and hardly any scientific work has been done on this subject. Some years ago, the League of Food Reform in this country collected a mass of information as to the diet in certain schools, but no precise information is available as to the effect of the dietaries on the children. The subject is, in fact, one of great difficulty. Individual cases are of no value, but when large numbers are considered, the effects of the food are difficult to trace. For example, very few schools undertake any kind of systematic inspection of the children term by term, or weigh them to ascertain their progress. It is probably hardly a practicable proposition. Then the amount of food taken and required will vary enormously with the habits of the individual. A boy who

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plays games actively, who usually runs instead of walking, and who is hardly ever voluntarily still, will require and take much higher quantities of food fuel than the boy of sedentary habits. The Food (War) Committee, as already shown, places the average requirements of boys and girls at 3,000 and 2,500 calories respectively, and fig. 36, already given, show the marked difference in caloric needs between a quiet and a very active boy.

Gephart [1] investigated the amount of food taken by 355 boys of various ages at a large school in New Hampshire. He found that the calories per head per day worked out at about 5,000, or more than one and a half times as many as the average requirement for an adult. There can be little doubt that metabolism is very active during the age period of about 13 to 17 or 18, and more calories are required per kilogram of body weight than in later life. But this does not necessarily mean that more fuel is required as a whole, since the total weight will usually be less.

As growth becomes less rapid, the calories required per kilogram of body weight gradually fall to the proportionate requirements of an adult, being considerably lower than at the age of 13. At the same time, some consideration must be had for the digestive system, and it is fairly certain that such a thing as taking an excessive quantity of food must not be ruled out. Physiologists do not appear to consider over-eating, but it is certainly a matter to be borne in mind in real life. Children are often greedy, or get into the habit of eating more than they actually require. It may also be that the food supplied them does not form a well-balanced dietary, and they are endeavouring subconsciously to repair the defect.

The body can, without any doubt, accustom itself to live at different metabolic levels. A person who habitually eats large amounts will live at a higher level than a person who eats smaller amounts. Everyone is familiar in ordinary life with the great variation in amount taken by individuals of

[1] Quoted by Lusk, *Science of Nutrition*, p. 558, from the *Boston Medical and Surgical Journal*, 1917, vol. lxxvi, p. 17.

fairly equal size and weight and of similar habits. It may be supposed that in the one case either the body is made to undertake an unnecessary amount of work, or the assimilation in the intestine is poor. Possibly both factors are at work. The person who eats less may, on the other hand, utilize the food better, and relieve the body of work which is not essential for its well-being. An overworked stomach and intestine is very unhygienic, and leads to distension and disturbance of function. Sir Arbuthnot Lane [1] considers that the intestinal stasis arising from an over-loaded bowel commencing in childhood is responsible for many of the diseases found only in later life. It is evidently impracticable in the ordinary wear and tear of life to be planning the daily menu with a close regard to calories, or to the precise nutritive values of the food provided. But a little knowledge and some common sense will suffice to produce a reasonably satisfactory dietary. Nature is capable of utilizing one food-stuff to replace others in a very extraordinary manner, as has already been explained ; but there are limits to this capacity, and some effort on the part of those who are responsible in each household should be made to provide suitable food.

It is unfortunate that comparatively few people have a sufficient knowledge of the rudiments of the basis on which a dietary should be arranged. Meat is often regarded as the most important article of food, especially for adults, while starchy foods are provided for children in large quantities. Within limits there is a greater need for carbohydrates on the part of the active child, but it also requires the other food materials. It is impossible here to enter into the question of a balanced dietary in further detail. It is hoped that the data given in Chapter XVI, and in the tables at the end of that chapter, kindly prepared by Professor Mottram, may form some guide as to the kinds of food which, when used together, will form a well-balanced dietary.

[1] *Lancet*, January 28, 1921.

CHAPTER XXVI

NOTES ON RICKETS AND SCURVY

THE investigations of physiologists during the last few years have brought rickets and scurvy within the field of the hygienist, since it has been shown that both these diseases are preventible. The health visitor, or anyone working among children, will be frequently meeting cases of rickets, while the bug-bear of scurvy is continually being held up in connection with the feeding of infants.

Rickets is a widespread disease, being very common in this country and in many other countries of Europe. It appears primarily as a disease of the osseous system, the bones becoming softened and the long bones bending, if any strain is thrown on them, as is the case if the child walks on them. There is little doubt that the whole bony structure is affected, and that it is due to some error of metabolism in the child. The lime which is deposited in the bones is reabsorbed into the system, leaving the bones unduly soft, and exposed to the pressure of the muscular action or to the weight of the body. Further, the formation of bone at the junction of the shaft of the long bones and the epiphyses of the joint becomes very irregular and results in an enlargement of the bones near the joint. The enlargement can be seen from outside, as the contour of the joint is altered, showing the swelling of the ends of the bones : this is usually especially noticeable at the wrist and ankles. The swollen appearance is partly due to a relaxation of the muscles and ligaments round the joint.

The junction of the ribs with the costal cartilage is another part generally affected, and results in an elevation at the point of union. This elevation can be felt through the skin, and is known as " beading " of the ribs, also as a " rickety

rosary.'' The closure of the fontanelles in the skull is delayed by the onset of rickets, the chief fontanelle increasing in size with the establishment of the condition. Of the six fontanelles in the fœtal skull, most are closed at birth, and the only one usually requiring attention after birth is the anterior fontanelle, which is situated at the site of the future junction of the frontal and parietal bones. Ordinarily this aperture is closed by about the eighteenth month by the growth of the bones, but if rickets supervenes this closure is delayed. The softening of the skull bones produces the square forehead or " caput quadratum " very frequently associated with rickety children.

The cutting of the teeth is delayed in rickets, and, when dentition is seriously behind time, this should lead to a suspicion of rickets. The average age for the appearance of the teeth is as follows :

TEMPORARY TEETH

		Months.
Lower central incisors	2	6–9
Upper incisors	4	8–10
Lower lateral incisors and upper and lower first molars	$\begin{cases} 2 \\ 4 \end{cases}$	12–15
Lower and upper canines . . .	4	18–24
Lower and upper second molars . .	4	24–30
	20	

Dental formula		Mo.	Ca.	In.	In.	Ca.	Mo.
	Upper	2	1	2	2	1	2 = 10
	Lower	2	1	2	2	1	2 = 10

PERMANENT TEETH

		Years.
First molars	4	6
Central incisors	4	7
Lateral incisors	4	8
First bicuspid	4	9
Second bicuspid	4	10
Canines	4	11–13
Second molars	4	12–14
Third molars (wisdom)	4	17–25
	32	

Dental formula		Mo.	Bic.	Ca.	In.	In.	Ca.	Bic.	Mo.
	Upper	3	2	1	2	2	1	2	3
	Lower	3	2	1	2	2	1	2	3

Dentition may be delayed in children who are not rickety by conditions which have produced any general debility.

Rickets is a disease which is rarely fatal, but it has very damaging effects which make it a matter of great importance to the well-being of the community. The weight of the body, acting on the legs, will cause curvature of the leg or bow-leg, a serious deformity and detrimental in walking, although not actually a cause of ill health. The repeated traction of the diaphragm on the softened ribs leads to depression around the chest at the site of internal attachment of this muscle, giving rise to a groove known as Harrison's sulcus. The action of the arm muscles on the chest tends to produce a general deformity of the chest, narrowing it slightly from front to back. These changes affect respiration, and rickety children are at a serious disadvantage if bronchitis or other respiratory trouble should overtake them : it appears that they are, as a whole, more liable to respiratory trouble than other children. The pelvic girdle may become considerably deformed, the cavity being narrowed from front to back, leading to difficulty in labour ; in extreme cases the spinal column also becomes deformed.

These detrimental effects of rickets have long been known, but it is only within about the last decade or so that attention has been drawn to the effects of rickets on the teeth. Lawson Dick [1] pointed out in 1916 that the effects of rickets were traceable in the teeth among school-children in whom the trouble itself had left little else that was obvious. This observation has been confirmed by other observers, and the whole subject has received great enlightenment from the researches of Dr. and Mrs. Mellanby, which are referred to again later. Mrs. Mellanby [2] showed that the teeth are softened in rickets just as is the rest of the osseous system. Further, the enamel is damaged and the teeth become irregular ; this is shown in fig. 59. The jaws of three puppies are shown, the only difference in the diet being in the kind of fat given. In the case of the dog 145 linseed-oil was given,

[1] *Proc. Roy. Soc. Med.*, 1916, vol. ix, p. 83.
[2] *Lancet*, December 1918.

and it can be seen that the teeth have got little or no enamel and are irregular. In the case of the dog 148 with cod-liver oil the enamel is perfect and the teeth well developed and regular. The dog with butter (dog 146) has fairly good enamel, but not so good as in dog 148. Dog 145 was a bad

FIG. 59.—Dog 145 received linseed oil as fat in its diet. Dog 146 received butter, and dog 148 cod-liver oil. In dog 145 the largest tooth has no enamel and the front teeth are irregular. In dog 146 there is some irregularity in the front teeth and the back teeth are not quite so well forward as in dog 148. The front teeth in the last dog are quite regular. All these dogs were of the same litter.

case of rickets. The bones of the other two dogs were normal.

The most important point in regard to the teeth from the hygienic point of view is that the condition of the first teeth has a marked effect on the condition of the permanent teeth. This is of serious import to the health of the child and adult, and leaves no doubt that every effort should be made to prevent even a mild rickety condition, if this is possible.

The visible deformities arising from rickets are not necessarily the most serious ones.

It has long been known that cod-liver oil is a good means of curing rickety manifestations, and the disease has been regarded as possibly due to a deficiency of fat in the food. It was realized, however, that this did not supply the full explanation of the cause. Puppies contract rickets fairly readily, and have been used for experimental purposes by various observers during the last few years. The Glasgow investigators attribute the onset of rickets mainly to lack of general hygiene, especially of exercise. Mellanby, however, disagrees with this, and believes that the diet is the responsible factor, and that the condition is dependent upon the presence or absence of vitamines in the diet.

Mellanby used a diet consisting of separated milk, white bread, and linseed oil, this last being taken to replace the cream of the milk ; yeast and orange-juice were also added to provide sufficient of vitamine B and of the anti-scorbutic factor. The puppies were six weeks old when the experiments were begun. On the above diet, which, except as to the bread, was given in definite amounts, the puppies developed well-marked rickets within about six weeks. If, however, cod-liver oil was used in place of linseed oil, rickets did not develop, and, in cases where rickets had already shown itself, a cure could be effected with cod-liver oil. A great number of experiments were carried out, and it seems fairly clear that the anti-rachitic substance must be the same as vitamine A. Mellanby found that confinement had no effect on the puppy if the diet was suitable. The position is not quite so simple as is stated above, as he found that an important factor was the rate of growth of the young dog. If the growth was slow the animal was less liable to develop rickets on a doubtful diet than if the growth was rapid. That is to say, if growth is taking place rapidly the growth factor provided by vitamine A is more urgently required to prevent rickets, or more accurately perhaps to maintain the proper balance and direction of growth. Generally the animal and fish fats were found to

be greatly more powerful in preventing rickets than vegetable oils, although there was considerable variety among these last.

It is impossible to enter into the valuable work done in detail. Those interested will find a discussion of the recent literature in the Report of the Medical Research Council, No. 38, to which reference has already been repeatedly made.

There appears to be an idea that the school of thought at Glasgow and Mellanby's experiments are widely at variance, but, in fact, there is no difficulty in seeing that there is truth in both. The experiments illustrate the facts which should be grasped by all hygienists, namely, that the systems of the body are interdependent and not independent. It is reasonably certain that diet plays a very important part in the production of rickets in children, and Mellanby's experiments demonstrate the importance of securing a sufficiency of vitamine A in the diet. Ordinarily this is obtained in milk in the early months of life, and later should be obtained in the mixed dietary, the importance of which has already been explained. Naturally butter will be a good ingredient to assist in the provision of vitamine A.

Given suitable conditions for the development of the various systems, an adequate supply of milk—either breast-milk, or, if needs must, of cow's milk with the cream—fresh air and cleanly conditions, satisfactory clothing of the right kind—in fact, good general hygienic conditions—the body, in the great majority of cases, will develop normally. If the age of weaning be unduly postponed and no additional food supplied, or if the food given be badly balanced as to its constituents, or if the child be kept in a hot, stuffy room with little or no fresh air, if its clothing be excessive or deficient, and its condition of cleanliness leaves much to be desired, some one or more systems will suffer and will inevitably affect the others. In one case the result may be that the child will not thrive, or that it may have indigestion, or it may develop rickets, according as to which

aspect of the balance necessary between the systems is
upset by the conditions of its life.

The knowledge at present available cannot tell us pre-
cisely which combination of adverse conditions is likely to
produce any given state ; but it is sufficient to tell us what
to avoid. We know that diet is of immense importance for
adequate growth, and that certain substances must be
present to keep that growth on the right lines. We also
know that, in order to secure health, there must be fresh air
and freedom of movement, sufficient warmth but not over-
heating, together with care in a variety of other matters.

There is no object in overloading the child with any
special vitamine just to make sure that it gets enough. .
The suggestion that all babies, whether breast-fed or not,
should take cod-liver oil in order to prevent rickets is really
an extravagant one. Let attention be devoted to the
mother's diet, on the lines already considered, and in the
case of the artificially fed baby the mixture should contain
some milk-fat to supply the vitamine necessary. Excess of
fat may produce a condition of fat dyspepsia which is not
easy to cure.

Mellanby's observation that the greater the rate of growth
the greater the liability to rickets is in entire conformity
with clinical experience. It is not the small, slowly growing
but healthy little baby that develops rickets, but the fat,
heavy, rapidly growing child, whose diet is badly balanced
and whose metabolism tends to be abnormal.

It is impossible to say that any one factor—diet, stuffiness,
etc.—is entirely responsible for the production of rickets.
Such a statement would be in direct contravention of
general experience, which teaches us that there is inter-
action between the systems, and that an unsatisfactory
state of one of them will also affect the others. It may
safely be said that at no time of life is the interdependence
more marked than in infancy, when the systems are im-
mature and have not attained the condition of stability
which comes with fuller development.

INFANTILE SCURVY

Infantile scurvy would appear to be produced by the absence of the anti-scorbutic vitamine in the dietary. The disease has always attracted great attention, rather by its dramatic nature than by its prevalence, especially in this country. The child which has developed scurvy is very ill and very fretful, is clearly in great pain on the slightest movement, and its condition altogether most heartrending. With the administration of the necessary factor an immediate improvement sets in, followed by an amazingly rapid restoration to health. Hence, therefore, it would appear that there is a disease affecting the whole body and leading, if neglected, to death, which is cured by the administration of one particular factor in the diet.

The natural and very proper sequence of events has been that there is great anxiety lest the food supplied to the infant should not contain a sufficiency of this factor. The most usual age for scurvy to develop is at the end of the first year of life, namely, at a time when the change from a milk diet to a mixed diet is taking place. It may, however, occur at an earlier or at a later stage. Nothing is known as to the amount of the factor required to prevent scurvy, and the tendency at the present time appears to be to give so much of it that it is quite certain there is no deficiency. The anti-scorbutic factor is found in good quantities in fruit and vegetable juices. Further, there is evidence that the factor concerned is sensitive to either prolonged or excessive heat.

A large number of experiments were carried out at the Lister Institute [1] with milk which had been heated for one hour at 120° C. and then fed to guinea-pigs or monkeys, the energy value of the diet being made up of substances which contain none of this vitamine. The animals developed scurvy on this diet. . Following on this, assertions have been made that the anti-scorbutic factor is destroyed if

[1] Barnes and Hume, *Lancet*, 1919, vol. ii, p. 233 ; and *Biochemical Journal*, 1919, vol. xiii, p. 306.

milk is heated. This, however, is too loose a method of speech. The experiments undoubtedly showed that prolonged boiling of milk had a destructive effect on the anti-scorbutic factor, but it did not show that " heating " milk did so without further definition of the term. This is one of the dangers already pointed out in connection with the loose methods of speech in regard to heated milk. No one boils milk for an hour in the feeding of infants, on account of its impracticability. There is no evidence whatever to show that milk which has been either heated quickly to 100° C. and rapidly cooled, or milk which has been pasteurised, as described in Chapter XXII, has been rendered unsuitable for infants. On the contrary, there is evidence against this. The weight-curves of infants available at hundreds of child welfare centres in this and other countries show that milk which has been pasteurised or rapidly boiled, or dried, contains an adequate supply of the growth factors, and also of the anti-scorbutic factor. The children do not develop scurvy on such a diet.

The upholders of the statement that pasteurised or rapidly boiled or dried milk produces scurvy in infants show a tendency to brush aside all the evidence in medical literature, and in the common knowledge of the whole profession. They state that the medical profession has failed to detect the cases of scurvy, or perhaps of incipient scurvy, which, it is alleged, must certainly have been present.

These assertions, while hardly doing justice to the powers of observation of the medical profession, are based on unfounded premises. It is assumed that experiments on guinea-pigs and monkeys are directly applicable to infants, and it is further assumed that there is no distinction between the highly heated milk kept at 120° C. for an hour, and the rapid methods of heating employed in pasteurisation or in drying milk (cp. p. 297 on the temperatures used in drying milk).

A series of experiments was conducted at the Lister Institute on monkeys of different ages and varieties. They were fed on a mixed diet, but which, apart from the milk

given, was believed to contain no anti-scorbutic vitamine. The results obtained with raw milk showed that about 100–150 c.c. per day was sufficient to protect from scurvy. The results with cow's milk varied a good deal : in one case, scurvy was produced when 200 c.c. of the dried milk re-made into the fluid was given, but in other cases it was not produced. The authors consider that the difference was due to the fact that some of the milk was obtained by drying during the winter months and some during the summer months, and that the difference in the results was due to the change in the cows' diet from dried foods to grass. In one case, where scurvy had already developed on 200 c.c. dried milk, the amount was replaced by 200 c.c. of milk which had been scalded in an open pan and left to cool. This produced a rapid cure of the scurvy, showing that the milk thus treated had not lost its anti-scorbutic properties.[1]

It may be that the milk in question had suffered some slight diminution in amount of the factor, but there is no evidence on this point. The milk heated by this process was found to have been at a temperature between 70° C. and 100° C. for about five and a half minutes. In most households, if the milk is boiled in an open pan, so soon as it has begun to froth it will probably be poured into a cold jug and left to stand in cold water, having fairly certainly been exposed to a high temperature for a shorter period than $5\frac{1}{2}$ minutes. Milk pasteurised in a double saucepan or in little bottles for infants would also have been heated for a shorter period, and does not at any time reach a temperature of 100° C. If, therefore, scalded milk produced a cure it may safely be assumed that pasteurised milk would have done so. These experiments do not bear the direct interpretation that dried milk would produce scurvy in infants. They show merely that some anti-scorbutic power is lost in drying, so that, given in amounts of 200 c.c. per day, it does not suffice to prevent scurvy in a monkey of unknown age. The relative amounts of the factor required by a monkey and an infant are not known, and the amounts of milk are not comparable,

[1] Loc. cit.

as the infant takes a great deal more than 200 c.c. per day. There is, in addition, a very important point to be considered, namely, whether the infant requires the same amount of vitamine per kilo of body weight as the other species. As its rate of growth is less it will, therefore, possibly require relatively less of the growth or protective factors; but this is not known. Again, the amount of the factor ordinarily present in human milk is not known; it is not unlikely that it may prove to be below that in cow's milk. The cow in summer lives on grass, during which period its milk is known to be richer in vitamines than in winter. If there is a diminution in the food factors as a result of cooking, then it must be supposed that the mother's food, and hence her milk, will be poorer in vitamines generally than that of the cow. But, if cooking does not destroy vitamines, then the heating suggested for milk will not do so.

Scurvy is not unknown in breast-fed infants. Morse,[1] in 1914, quoted three cases of scurvy in breast-fed babies. In this case it is reasonable to assume that the mothers' diet was deficient in accessory food factors.

For the present it will be sufficient to take clinical evidence as convincing, and it is not unreasonable to suppose that, when the war and its abnormal conditions have faded a little into the background, investigation will be undertaken into the question of vitamines in relation to normal dietaries and normal methods of cooking and of heating milk. It may be that there is some loss of all factors in certain or all of the ordinary processes of cooking, but it is reasonably certain that there is a margin of such substances in the food which allows for some destruction in the process of cooking, while leaving an adequate supply in the food taken.

The reader may be reminded that milk should not be heated twice: this has been found to be a source of scurvy (cp. p. 271); but how far it is due to the length of time over which such milk will almost certainly have been kept, and how far to the double heating, is not known. In the meantime, it will suffice to bear in mind the general requirements

[1] *American Journal of Obstetrics*, 1914.

of the body for both adults and infants, remembering that the diet of the mother should contain the necessary food factors. She should be encouraged to take a varied diet, which should include vegetables and fruits, both on account of her own health and that of the child.

There is no harm in adding fruit-juice to the food of an artificially fed child, but equally it has not been shown to be really necessary, and only adds to the expense and trouble of the mother.

CHAPTER XXVII

GROWTH AND GROWTH FACTORS IN INFANCY AND CHILDHOOD

GROWTH in infancy and later depends upon many factors. There are certain general directions of growth which, so far as may be, operate in all infants and children : these are the internal factors ; but they can be and are known to be widely modified by external circumstances, notably by diet.

During the first few weeks of life the infant loses weight, the day after which it regains its birth-weight varying from the fifth to the tenth or even the fourteenth day. Much work has been carried out with a view to ascertaining the cause of this drop in weight and whether any advantage could be effected by devising means for preventing it. It has been found [1] that, although loss of total weight occurs, there is a positive nitrogen balance, which indicates that the building up of tissue is progressing side by side with loss of weight. If a newly born child was fed by a wet-nurse whose milk has passed the colostral stage, a negative nitrogen balance was then found.[2] The loss is due largely, if not entirely, to loss of excreta and water which, during the early days of life, is not replaced in the food. There is the loss by the passage of meconium and urine, in addition to the loss from the lungs and skin. The amount of fluid given off from these sources is considerable, but the amount of fluid taken in is small. In the early days after birth the mammary gland is giving very little secretion, although that which is given is rich in nitrogen. Camerer [3] has stated that the loss

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[1] Birk. *Monats. f. Kinderh.*, 1910, vol. ix, p. 595 ; Griffith and Gittings, *Arch. of Ped.*, May 1907.

[2] Birk., loc. cit.

[3] Quoted by Schlossmann and Pfaundler, in *Diseases of Children*, **vol. i.**

in weight is the same as the total losses from the sources mentioned, minus the amount of fluid taken. The experiment was carried out on a newly born girl who was the fifth child. Thus the gland got into working order more rapidly than is the case with the first or second children.

Days.	Amount of milk (in grammes).	Losses in grammes.		Loss from skin and lungs.	Sum of losses.	Change in body-weight.
		Urine.	Fæces and meconium.			
1	10	48	51 ⎰meco-	98	197	— 187
2	91	53	26 ⎱mium	79	158	— 67
3	247	172	3 ⎰fæces	85	260	— 13
4	337	226	3 ⎱	92	321	16

Rott [1] has shown that during the process of the loss of weight the blood becomes more concentrated, the reverse occurring as the weight again rises, the blood becoming normal when the birth-weight is regained. The loss of weight can be prevented by giving additional human milk during the early days of life. The prevention of the loss did not, however, after a few weeks had elapsed, show that any advantage had been derived by the infant.

The loss of weight is rapidly regained by breast-fed babies, probably owing to the very rapid increase in the amount of breast-milk. The amounts of breast-milk taken which are shown on fig. 56 on p. 291 show that the average daily amount of breast-milk obtained after the first week is between 500 and 600 c.c., or between $17\frac{1}{2}$ and 21 ozs. Now, the artificially fed infant cannot be given as much modified cow's milk as this, and for reasons which have already been explained receives usually not more than about one-half this amount, and may receive less than that. Hence the regaining of the birth-weight is a slower process than with the breast-fed baby.

The weight-curve alone does not represent the growth which is taking place, and it is necessary to take into consideration the growth in length as well as the growth in

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[1] Rott, *Zeit. f. Kindah.* 1, 1910, p. 43.

weight. For example, a child fed on foods with much sugar, such as condensed milk, may become very heavy, but it will not necessarily be growing proportionately in other respects. Unfortunately, growth in length is more difficult to measure than growth in weight, as infants do not readily lie down flat so as to give accurate length-measurements. They do not always readily sit or lie still in a scale-pan, but it is usually easier to weigh them accurately than to measure them. No comprehensive investigations have been published showing the simultaneous growth in weight and length of the infant in its early days, and there is evidence that the two forms of growth are to some extent independent.

The growth in weight will be considered first.

Numerous investigations have been made of the weight-curves of infants, both in this and in other countries, and nearly everyone is familiar with the weight-curves of supposedly normal infants which are shown as a red line on the charts used at many child welfare centres. In actual fact there is no absolute rate of growth in weight which a child could show if it is to be regarded as normal, nor is the rate of growth constant. As a whole the rate of growth is greater during the weeks after the birth-weight had been regained and gradually slows down thereafter. In the first few weeks an increase of weight of as much as 8 ozs. may be recorded in a week, but this will gradually fall to 6 ozs. or later to 4 ozs., and towards the second year of life to about 2 ozs.; but these figures are only the roughest indication of the child's progress. Very few children show a weekly increase which is the same for any two weeks in succession. Thus, a perfectly healthy infant may gain 10 ozs. one week and 6 ozs. the next, followed by a gain, say, of 9 ozs. and 7 ozs. There is no fixed figure, and, so long as a gain approximating to the average is shown, no further close comparison with so-called normal weight-curves need be made. Even where large numbers of children are investigated and the average weight taken, great fluctuations in the rate of increase are shown. The Berlin material worked up for the Local Government

SHOWING PERCENTAGE RATE OF INCREASE FOR EACH
PERIOD OF EIGHT DAYS ON THE INFANTS OF BOTH SERIES
(CONTROL & BOILED COWS MILK) UP TO THE AGE OF EIGHT
MONTHS

FIG. 60.

Board by Lane-Claypon [1] shows the wide variations both
in breast-fed and bottle-fed babies.

Figure 60 shows the variation.

The plain line shows the percentage rate of increase
each period of eight days of the breast-fed babies (Series I)
and the dotted line that of the artificially fed ones (Series II),
up to about the end of the eighth month of life. It will be
noticed that the early high rate of increase falls sharply after
about the first six or eight weeks, and then falls more slowly,
with great weekly fluctuations throughout the whole period
under investigation. These must not be taken as absolute
rates, but they show that, even when large numbers of
weights are taken, there is still no regularity of increase.

Mothers and nurses often get agitated and distressed
because the baby is not putting on weight regularly, whereas
such a process would be the exception and not the rule.
The general trend of the weight-curve should be upwards,
but a temporary drop in weight is usually found with any
general disturbance, such as a cold or a cough, a mild attack
of diarrhœa, or other ailment. The weight-curve does not
take a straight but a zig-zag path in the great majority of
cases. Even when 130 breast-fed children were examined
collectively [2] the resulting weights did not present a regular
curve, but an irregular one (cp. fig. 61).

The plain line shows the breast-fed babies and the dotted
line the artificially fed ones. After the first few days there
is, comparatively, little difference in the *rate* of growth of
the average breast-fed baby and the artificially fed baby,
although the Berlin material seems to show that the actual
average weight of the bottle-baby is slightly below that of
the breast-fed baby during the first six months of life, after
which little or no difference can be detected. This is shown
in fig. 62, where the weights of 300 breast-babies and 204
bottle-babies have been charted. [3]

[1] Lane-Claypon, Report to the Local Government Board, New Series,
No. 63.

[2] Ibid.

[3] The bottle-fed babies were all fed on cow's milk of good quality, which
had just been brought to the boil and afterwards cooled and modified.

It must not, however, be thought that the curves shown and the fact that the rate of growth is almost identical in the two series prove that there is no advantage in breast-feeding. This would be entirely erroneous. The records taken for investigation were not consecutive because when the child had died during the first year of life or ceased to attend, the

SHOWING THE AVERAGE WEIGHT OF 130 INFANTS EXCLU·
-SIVELY BREAST-FED & OF 119 INFANTS EXCLUSIVELY FED
UPON BOILED MILK UP TO 200 DAYS OF AGE. OF THE
119 INFANTS 78 HAD NEVER BEEN BREAST-FED AND 41
HAD BEEN BREAST-FED FOR 8 DAYS OR LESS.
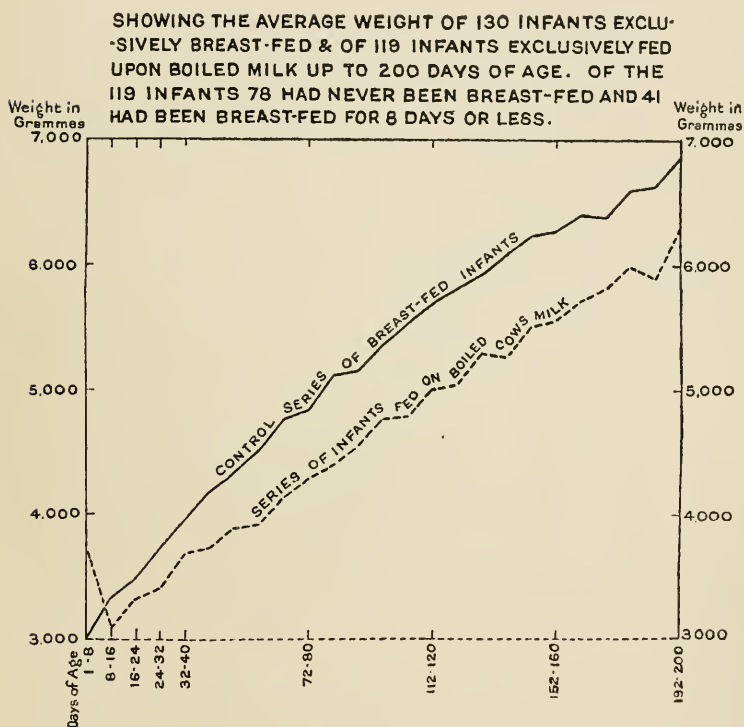
FIG. 61.

whole record was discarded, whether the child was breast-fed or bottle-fed. The records examined showed clearly what is a commonplace to those engaged in work among children, that the breast-babies suffered from many fewer minor ailments (all recorded on the charts examined) than did the bottle-babies. Further, there is already abundant evidence

SHOWING THE AVERAGE WEIGHTS OF THE INFANTS OF SERIES I (CONTROL SERIES, CHIEFLY BREAST-FED) & OF THE INFANTS OF SERIES II (FED ON BOILED COWS'MILK) IN PERIODS OF EIGHT DAYS
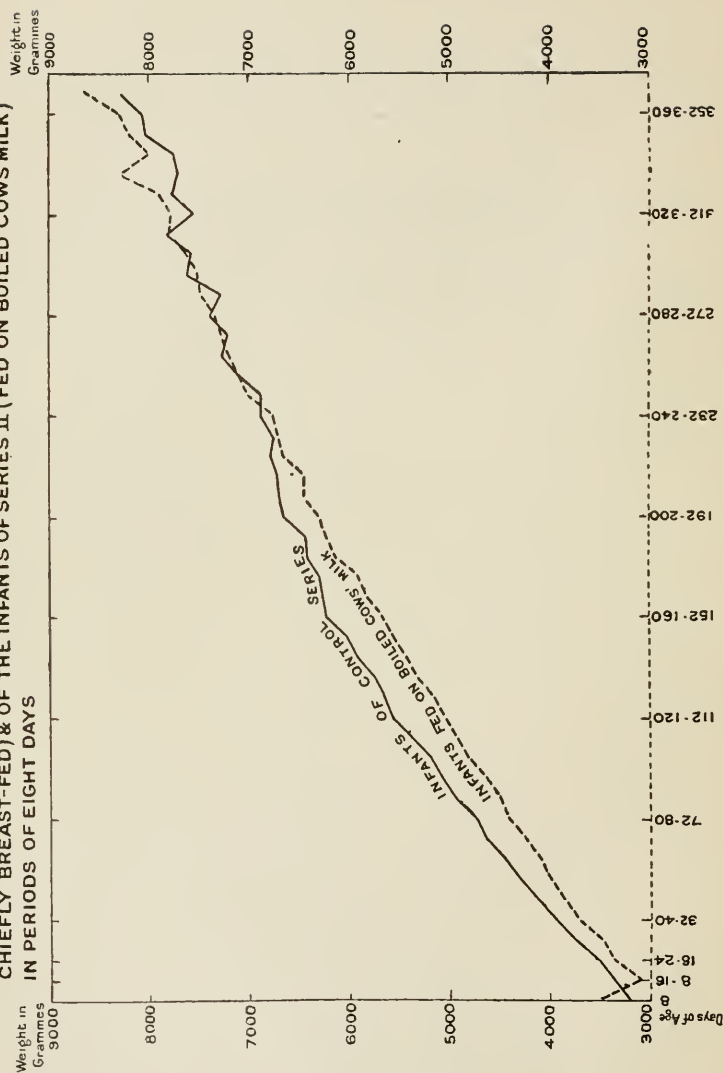
FIG. 62

showing that it is bottle-babies who die in much greater numbers than breast-fed babies during the first year of life.

After the first year of life the growth in weight is relatively slow. Weight figures have been worked out by the Anthropometrical Society giving the average weight for both boys and girls at different ages. From these it is seen that there are slight sex differences : girls as a whole grow more rapidly in weight between the ages of 13 and 16, while boys show the most rapid period of growth slightly later in life. Table C shows the figures in their entirety. Further data will probably be available shortly, as investigations are proceeding from Oxford University.

TABLE C.—AVERAGE HEIGHT (WITHOUT SHOES) AT DIFFERENT AGES
Boys—heavy type. Girls—light type

Age last birthday.	Height— inches.	Increase.	Age last birthday.	Height— inches.	Increase.
Birth.	**20·6**		11	**53·5**	**1·7**
	20·5			53·1	2·1
1	**29**	**8·4**	12	**55**	**1·5**
	28·7	8·2		55·6	2·5
2	**32·5**	**3·5**	13	**57**	**2**
	32·5	3·8		57·7	2·1
3	**35**	**2·5**	14	**59·3**	**2·3**
	35	2·5		59·8	2·1
4	**38**	**3**	15	**62·2**	**2·9**
	38	3		60·9	1·1
5	**41**	**3**	16	**64·3**	**2·1**
	40·5	1·5		61·7	0·8
6	**44**	**3**	17	**66·2**	**1·9**
	42·8	2·3		62·5	0·8
7	**46**	**2**	18	**66·9**	**0·7**
	44·5	1·7		62·4	—
8	**47**	**1**	19	**67·3**	**0·4**
	46·6	2·1		62·7	0·3
9	**49·7**	**2·7**	20	**67·5**	**0·2**
	48·7	2·1		62·9	0·2
10	**51·8**	**2·1**	21	**67·6**	**0·1**
	51	2·3		63	0·1

Holt [1] finds that growth is more rapid in summer than in winter. Weight can vary within wide limits, and the child be healthy ; below a certain increase, however, there is usually either a deficiency of diet or some diseased condition.

[1] *American Journal for Diseases of Children*, 1918.

A too rapid increase in weight may also be a danger signal. The very fat child is by no means necessarily strong. In the early months great obesity will probably be due to a badly balanced diet and is often accompanied by rickety changes. In a breast-fed baby rickets may not be present, but the abnormally fat baby is usually more liable to colds and bronchitis than his brother or sister whose tissues are less infiltrated with fat. The weight will evidently vary to some extent with the nature of the diet and with the amount of exercise taken. Everyone, however, is familiar with the person of large appetite who does not grow fat, and with the person of small appetite who does not grow thin. These are intrinsic problems of metabolism outside the scope of this work, and still requiring investigation.

In cases where the amount of adipose tissue is excessive at any age there may be deficiency of thyroid secretion ; the condition is then pathological, and requires medical treatment.

TABLE D.—AVERAGE WEIGHT AT DIFFERENT AGES

Boys—heavy type. Girls—light type

Age last birthday.	Weight— pounds.	Increase.	Age last birthday.	Weight— pounds.	Increase.
Birth.	**7·5**		11	**72**	**4·5**
	7·2			68	6
1	**20·5**	**13**	12	**76·7**	**4·7**
	19·8	12·6		76·4	8·4
2	**26·5**	**6**	13	**82·6**	**6·9**
	25·5	5·7		87·2	10·8
3	**31·2**	**4·7**	14	**92**	**9·4**
	30	4·5		96·7	9·5
4	**35**	**3·8**	15	**102·7**	**10·7**
	34	4		106	9·3
5	**41·2**	**6·2**	16	**119**	**16·3**
	39·2	5·2		113·1	6·8
6	**44·4**	**2·2**	17	**130**	**11 ·**
	41·7	2·5		115	2·4
7	**49·7**	**5·3**	18	**137·4**	**7·4**
	47·5	5·8		121·1	5·6
8	**54·9**	**5·2**	19	**139·6**	**2·2**
	52·1	4·6		123·8	2·7
9	**60·4**	**5·5**	20	**143·3**	**3·7**
	55·5	3·4		123·4	—
10	**67·5**	**7·1**	21	**145·2**	**1·9**
	62	6·5		121·8	—

Growth in length appears to be to some extent independent of the weight. Pfaundler states that the length of a child varies as the cube of the age, the age being taken from the date of conception, not from the date of birth. He finds conceptional age to be equal to the cube of the length multiplied by a constant which is 4·75. Conversely, if the length is known the conceptional age can be ascertained. Evidently this will give only the average figures, and there will be wide variations within normal limits.
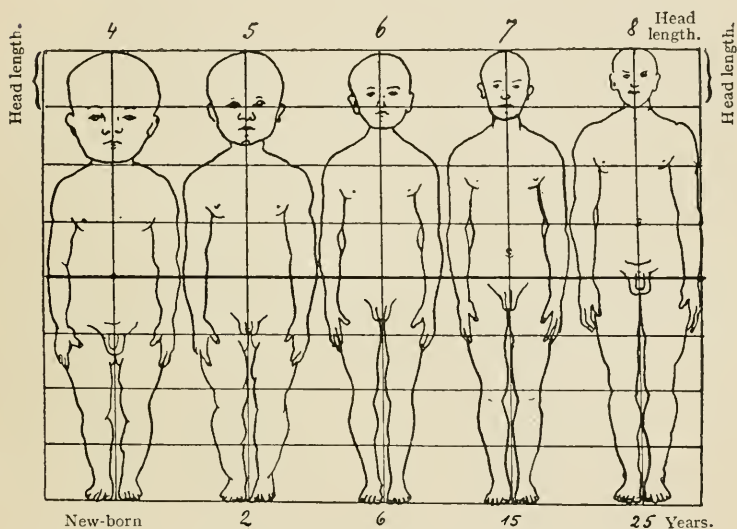
Fig. 63.—Showing the proportionate size of the head and the rest of the body at different ages.

The average height has also been worked out by the Anthropological Society, for boys and girls, and the figures are given in Table D.

Further comprehensive investigations are promised from America, but have not as yet been published (*Woodbury Jour. of Phys. Anthrop.*, 1919, vol. ii, p. 196).

The child's head at birth is relatively large in proportion to its total length ; after birth the body grows proportionately more than the head, as is seen in fig. 63.

The Relation of Feeding to Growth.—Of recent years the investigations on vitamines have been rightly held to have a bearing upon infant feeding. This is a subject of great importance, but the very fact of its importance and of the far-reaching nature of any conclusions drawn make it imperative that no hasty or rash deductions should be made.

It should, however, be borne in mind that abundance of vitamines alone, without sufficient food-stuffs, will not secure adequate growth, any more than will abundance of food-stuffs without the necessary vitamines. The great advantage of a mixed dietary for the fuel value is that thereby all the vitamines are more likely to be present in sufficient amounts.

The experiments on rats made by Hopkins and by McCollum show the importance of the vitamines for growth. In Hopkins's experiments the vitamines present in so minute a quantity as 2 c.c. of milk sufficed to make all the difference between growth and its complete absence (cp. fig. 38). It is believed that both fat-soluble A and water-soluble B are concerned with growth, and the anti-scorbutic factor, if not itself directly concerned, will, if absent, after a time cause such disturbances of metabolism as to inhibit growth. It must be assumed that it is of vital importance to the child that its diet should contain a sufficiency of these food and growth factors. But up to the present there is little or no evidence as to the amounts of these factors which are essential to infants or adults.

Much work has been done [1] on the amounts of the various foods which protect against scurvy in guinea-pigs or against beri-beri in pigeons. The amounts have been carefully worked out, and there is every reason to believe that they are accurate. It is not, however, possible to apply these results categorically to infant feeding : far from it ; experiments on animals, while of the utmost value as a general basis, cannot be assumed as directly applicable in all details to human beings, and especially to infants. Guinea-pigs, rats, and infants are all different. They are severally born in different stages of maturity, and the duration of the time

[1] Cp. Report of Medical Research Council, No. 38.

during which they are wholly dependent on their mothers also varies. Further, there is no evidence whatever that equal amounts of accessory substances are required by different species of animals. In fact, the assumption is that it is not so, since rats do not appear to be liable to scurvy, even when dietaries which would be supposed to induce it are given. On the other hand, rats are very suitable animals to use for investigations into the other accessory factors.

Inasmuch as human beings take the greater part of their food cooked, the resistance to heat of these factors becomes important. Especially is this the case in war time when tinned and concentrated foods have to be widely used by armies on the march. A great part of the investigations have, therefore, very naturally been carried out on foods which had been subjected to a high or a prolonged temperature, sometimes to both. Normal infant or adult feeding is not really concerned with these abnormal temperatures. It is a matter of common experience that tinned foods are not so nutritious as fresh foods, and that dishes that have been repeatedly cooked or warmed up are not so good as freshly cooked ones. The evidence as to the heat-resisting power of vitamines A and B is somewhat conflicting. It seems, however, that they are capable of withstanding a temperature of 100° C. for at any rate some minutes, if not longer. Generally, therefore, the temperatures ordinarily employed in cooking may probably be taken as having little or no effect on these two vitamines. It is undesirable on all grounds to boil vegetables or any kind of food longer than is really necessary to make it tender or to render it safe for eating. There is nothing to be gained by prolonging the period of heating, but the reverse. It is not always appreciated that, even though the temperature of an oven when used for roasting or baking may be well over 200° C., the temperature in the inner part of the object cooked will never reach anywhere near that figure. The temperature inside a well-done joint of meat should only reach 72° C., or the whole joint will be over-done. The temperature

inside cakes and puddings has not apparently been investigated, but there is no reason to suppose that there would be any fundamental difference in principle. Most things cook at a temperature below that of boiling point of water, as is evidenced by haybox cookery. Here the temperature must fall rapidly at first on being placed in the box, and the cooking must be carried out at a heat figure well below boiling point.

The addition of alkali is stated to act detrimentally upon vitamines A and B ; but, apart from this, practically nothing is known as to the effect on these vitamines of the ordinary processes employed in domestic cookery. It may be that a portion of the vitamines is destroyed by the temperatures used, but if this is so (and it has not yet been shown to be the case) then presumably the amounts present in an ordinary mixed dietary are sufficiently in excess to admit of some loss in cooking. Barnes and Hume,[1] working with dried milk, found no direct evidence of any loss of vitamines A and B, although their experiments were not directly concerned with these bodies.

It is plain from the weight-curves of infants fed on boiled or on dried milk that, even if there is a loss of the growth factor, there is still an abundant supply remaining in the heated products, and this although milk is not a food particularly rich in vitamine B.

There is no apparent object in taking amounts of vitamines greatly in excess of requirements, and so long as a sufficiency is secured no anxiety need be experienced. A mixed dietary has long been realized to be of importance both for infants and adults. This is further emphasized by the work on vitamines A and B, and our knowledge of the food-stuffs in which these are relatively plentiful is useful in order that an adequate supply may be assured. It is very likely that enough attention has not as yet been devoted to the importance of a suitable mixed dietary for the pregnant and nursing woman. On the other hand, as has already been pointed out, although milk contains all the vitamines,

[1] *Biochemical Journal*, 1919, vol. xiii, p. 306.

it is not rich in any other than vitamine A and is for other
reasons unsuitable to play a large part in the necessary diet.

The Development of the Muscular System

A few remarks seem necessary on the development of the
muscular system.   This is, of course, closely associated with
the development of the bones and joints, but the joint effect

Fig. 64.—Two days' old child.

is shown in the condition of the muscles.   A well-knit bony
system implies good muscle tone and vice versa.

The following pictures show the gradual development,
during the first year of life, of the muscular tone.   In fig. 64
the child has little or no power of supporting itself, but
wobbles helplessly.   In fig. 65 it is seen to be able to raise
its head, and there is a suggestion of dawning intelligence in
the attitude.   Later, in fig. 66, it has sufficient muscular tone
to hold the body fairly upright when supported.   In fig. 67

it is just able to stand upright when supported with two hands. The expression of the face suggests that the whole is somewhat of an adventure, and the position of the feet

FIG. 65.—Breast-fed baby, six weeks old.

shows that the child is only held upright by the hands at the side and back. Fig. 68 shows the child almost standing alone. The feet are more firmly planted, slightly apart

FIG. 66.—Breast-fed baby, 3½ months old.

so as to serve as a support, and the whole attitude of the body expresses relative ease as compared with the preceding figure.

After the child can walk easily it is important that it should be required to walk and sit straight. It should not be allowed to loll about with its arms and body held in any curious position. The need for a correct posture during sleep has already been mentioned, and the position when awake is also of great importance. When the whole system is pliable and is growing a deformity may result if the child is allowed to adopt continually a faulty posture. Curvature

Fig. 67.—Breast-fed baby, six months old.

of the spine, while due to a variety of causes, may be produced by a continued incorrect position. Too often children are allowed to slouch instead of holding themselves upright and being a little brisk in appearance. These postures in walking and sitting are often merely a habit, and can be altered quite easily with a little persistence on the part of those in charge. If the school furniture is too low, or the relation of desk and seat incorrect, then the fault may

not lie with the child. Details as to school furniture will be found in other text-books on hygiene.

Again, if the light is bad the child may bend over or turn the body at an angle so as to secure sufficient light. The muscles are placed for prolonged periods in faulty positions
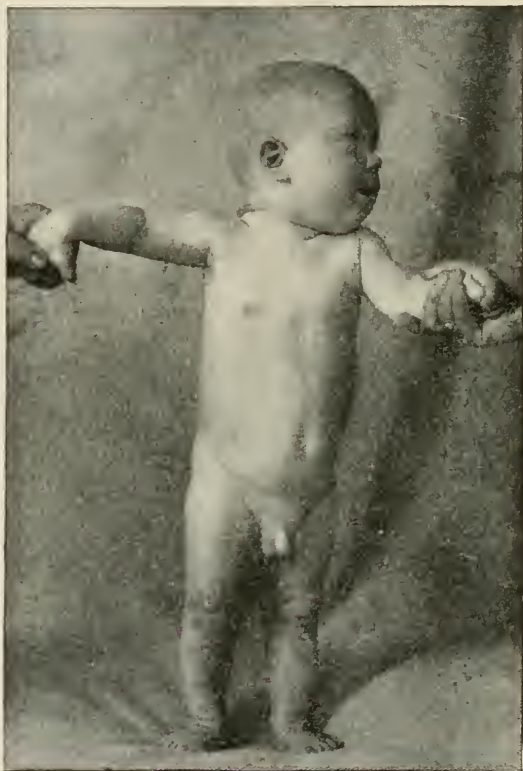
Fig. 68.—Breast-fed baby, nine months old.

and acquire the habit of such a posture, dragging the bones to which they are attached out of their true position.

The carrying of heavy weights may also produce deformity. The small girl who carries on her arm a baby looking nearly as large as herself will stand a great risk of deformity of the spine and its muscles. She will usually carry the child

on her left arm, leaving the right arm free for other purposes. Any heavy weight which is frequently carried by any group of muscles will have a similar effect. The position required for some musical instruments may lead to some degree of spinal curvature if care be not taken to see that the child stands straight.

The danger of faulty posture should by no means be ignored. Not only is it of great importance for the whole muscular system, but it undoubtedly exercises an influence on the mind.
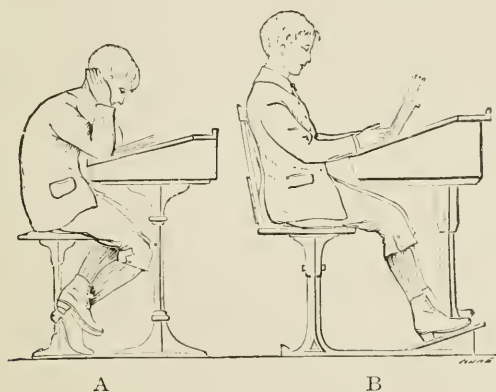
Fig. 69.—A, faulty position and furniture. B, correct position and furniture. Note the relative positions of the trunk, arms, and legs. Note also the rest for reading.

Figs. 69–71 show the attitudes likely to cause trouble and simultaneously convey an attitude of mind.

Attitudes of mind are assumed by both children and adults as readily as attitudes of body. If a child be allowed to be idle and discontented (the two frequently go hand in hand) its mind will take that attitude. If, however, it be required gently but firmly to be helpful and contented, its mind will acquire those habits, and will influence its whole life and career. Those who contend that mental characteristics cannot be altered, presumably mean that they are difficult to alter in adult life ; they are certainly more difficult to change after childhood has been passed, but the difficulty

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often lies in our own disinclination to exercise the needful discipline and self-control.

The spoilt, badly-brought-up child is very often a nuisance
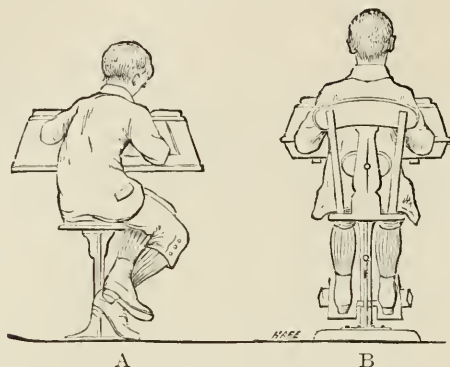
Fig. 70.—A, Faulty position of desk for writing.   B, correct desk and posture.   Here also note position of trunk, arms, and legs.

to himself and others on reaching adult life.   How early the characteristic habits and attitudes are adopted it is difficult
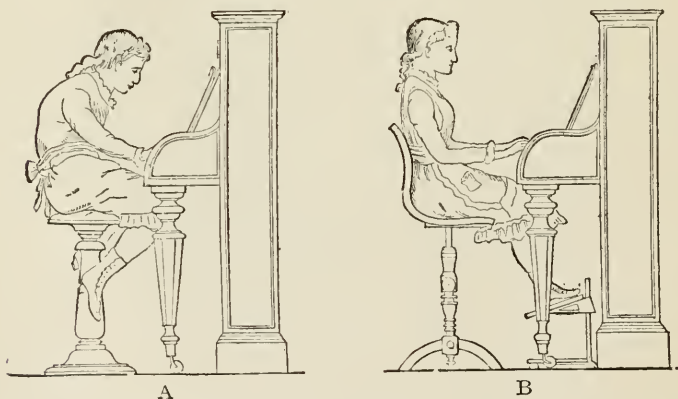
Fig. 71.—A shows faulty posture at the piano.   B shows correct posture

to say.   There can, however, be little doubt of the immense, often unconscious influence of the habits formed or allowed to form during the early years of childhood, which may

affect the whole later life for good or ill. For each individual makes so many of his or her own circumstances. It may be that much also is beyond our own control, but the indolent mind and body, which will not grasp the chances offered, are more often to blame for our misfortunes than we are perhaps willing to admit. The influence of the mind on general health is now widely recognized, and it is, therefore, of importance that such attitudes of mind as will tend to good health should be encouraged or adopted. A cheerful habit can be acquired quite as well as a grumbling one, and they who would be healthy in both mind and body must seek to obtain dominion over the body and to cultivate that self-control without which little can be achieved in life. So will they retain health, and secure happiness, and be enabled to perform those duties which fall to their lot in the world.

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